ANNUAL REPORT

TO THE

ATOMIC ENERGY CONTROL BOARD

ON THE

REGULATORY RESEARCH AND DEVELOPMENT PROGRAM

COVERING THE PERIOD

1 APRIL 1986 to 31 MARCH 1987

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This is the third detailed annual report for the Regulatory Research and Development Program. Prior to FY 84/85, the Program, which was initiated in 1976, was reported only in the annual reports of the AECB.

The administration of the program is described in a document, INFO-0157, Description of How the AECB Research and Development Program is Administered. The program for FY 86/87 is described, generally, in BMD 86-39 and was approved by the Board on March 13, 1986.

The overall objective of the research program is to produce pertinent and independent information that will assist the Board and its staff in making correct, timely, and credible decisions on regulating atomic energy.

Within the framework of the general objective, the specific objectives are:

(i) to verify information, claims or analyses from licensees in support of licensing actions;

(ii) to fill gaps in knowledge to enable the Board to contribute to the establishment of health and safety requirements or guidelines or to aid in arriving at licensing decisions ("licensing decisions" means decisions on establishing licence conditions or taking actions pursuant to a licence as well as decisions on whether or not to grant, amend, suspend or revoke a licence);

(iii) to stimulate licensees to do more work on certain topics relating to health, safety or security;

(iv) to develop information on the regulatory process and the evaluation of the regulatory process;

(v) to develop equipment or procedures to enhance health, safety or security in those cases where the industry is not competent or inclined to do so; and

(vi) to enhance the competence of the Board and its credibility in the eyes of licensees and the public.

Part 1 of this report reviews the performance and process associated with the technical and administrative management of the program by AECB staff. Part 2 reviews the technical results of the program according to ten Mission Objects.

The funds expended on the ten Mission Objects are given in Table 1.

The membership and activities of review panels (see 1.2.2) are given in Appendix A (See also 1.2.2 for an overview of the review panel concept). Appendix B contains the project summaries and the status of individual projects. Appendix C contains a list of the project numbers and titles.

1. OVERVIEW

1.1 Performance

In FY 86/87 151 projects were active of which thirty-six projects were completed. The original budget of $3258K for the program was reduced by $100K to establish a contingency fund for the AECB and a further $165K as a result

of a Treasury Board restraint measure, leaving $2993K. Of the remaining program budget allocation of $2993K, $2593K was spent on projects and $80K was spent on administrative charges for the Department of Supply and Services (DSS). Spending associated with project review panels amounted to $50K. The program contributed to the financial support of two workshops (described in more detail below) in the total amount of $12K and $19K for travel associated with the uranium mine radiation safety course. Of the remaining $239K, $115K lapsed and $124K were used for other purposes.

The projects are designated by one of four categories: category 1 for projects which were to be funded in FY 86/87 (category 1* means that the project was in progress at the start of FY 86/87), category 2 for projects awaiting the outcome of a previous project, category 3 for projects which were to be funded only if money became available, and category "NEW" for projects which arose during the year, after the program had been established initially.

The summary statistics of the program are as follows:

	Number of Projects	Original Estimate	Actual Spending
- in progress or planned at the beginning of the period (cat. 1*, 1 and 2)	129	$3,921K	$2,319K
- planned for initiation if money became available (cat. 3	21	963K	12K
- added during the period ("NEW")	25	-	262K
- cancelled or postponed	27	1,495K	-
- contract completed (acceptable final report received) and final payment made	59	825K	621K
- in progress at the end of the period	80	2,725K	1,961K
- remaining at the end of the period for which there was insufficient funding	9	438K	-

The total dollar value of all proposed projects was $4884K. This was approximately $1891K greater than the available budget of $2993K. All of the proposed projects were classified as category 1*, 1, 2 or 3, the 129 category 1*, 1 and 2 projects amounting to $3921K, which alone exceeded the budget by $928K. (See above for definitions of the project categories.)

In FY 86/87, the budget remained at its nominal value which it had attained in FY 85/86 following increases approved by Treasury Board for FY 85/86 and the previous two fiscal years. Following the trends of the previous years, the budget was divided, at the start of the fiscal year, approximately evenly between the two research sections. During the fiscal year two transfers (totalling $150K) were made from the Safety and Safeguards Section to the Health Effects and Regulatory Documents Section. These transfers, mainly into the area of Mission Object 8 (Health Physics), were made as a result of increased demands and changing priorities within the program.

The Safety and Safeguards Section operated below full strength for almost three months, owing to the transfer of one Project Manager to another division within the AECB. The Health Effects and Regulatory Documents Section operated at full strength during FY 86/87.

There has been some time lag between the rapid increase in the size of the research budget and the ability of the research sections to commit fully an entire year's budget. This has resulted in budgetary lapses for the past several years. However, by FY 86/87, a number of factors have come into play that have resulted in a fully-committed and almost fully-spent budget. First, the research sections are now up to full strength in personnel. The demands on the program have resulted in more multi-year and more costly projects, which contribute to better utilization of staff resources. Better planning has resulted in the commencement of projects earlier in the fiscal year. The development of quicker responses to cancelled or deferred projects have also played a role in increased efficiency, as has an improved ability by staff to respond to projects whose spending estimates may have been suddenly reduced, thus allowing other projects, held in reserve, to be activated during the fiscal year.

Several administrative procedures have been introduced to streamline the internal approval and contracting out procedures. For those projects requiring Board approval, previous experience has shown that significant effort is often required to provide answers to questions that arise during Board meetings. Consequently, increased attention was placed on the preparation, completeness and timely presentation of Board Member Documents. Cost-sharing with other agencies, where this is a factor, has been pursued in an effort to advance the initiation of a project as well as to increase value for money. Work plans were introduced to enhance project management efficiency for each project manager. Priorities were set on each new project to be initiated in FY 86/87. The dates for the initiation of work by the project managers and for the implementation of each contract were followed more closely, with the result that the budget was, for practical purposes, fully committed by mid-year.

Fewer projects proposed by the licensing divisions and by the Radiation Protection Division (RPD) were withdrawn or cancelled in FY 86/87 than in previous years. This reflects a much more detailed screening of proposals from individuals than in previous years, by the proponent divisions before a project is proposed to the program managers. It has also become a more rigorous practice that projects proposed by the research sections themselves must have the support of one of the licensing divisions, or of RPD, before they are proposed for management review.

The overall result was a program that had broader AECB support, which support was less likely to wane with time, thus increasing the smoothness and efficiency of initiating new projects.

As usual, however, many contractors were not able to carry out the work at their initially-proposed rate of spending, resulting in some of the committed funds reverting to an uncommitted state. Treasury Board rules do not permit over-commitment of the budget to compensate for this effect. In the end, these factors had the usual result that a portion of the budget ($115K in

FY 86/87) remained unspent. This amount of underspending was much lower than in recent years and constituted a substantial improvement in operational performance from previous years, and represented a measure of the maturity attained by the program.

A number of associated activities were supported by means of the R & D budget. The AECB contributed $7K to the financial support of a workshop on Computerized Record Linkage in Health Research, in May 1986, organized by the University of Toronto and the University of Ottawa (The proceedings of this Workshop have been published). Another contribution of $5K was made in FY 86/87 to the Canadian Public Health Association to sponsor a workshop on Health Aspects of Environmental Impact Assessment, which took place in May 1987.

1.2 Process

1.2.1 Authorization

As decided by the Board at its meeting in January 1984, planned projects costing the AECB $100K or more are individually submitted to the Board for approval, and those costing $50K-100K are submitted to the President for approval. The Director of the Regulatory Research Branch may approve those costing up to $50K.

1.2.2 Review Panels

Although panels have been formed ad hoc in the past for certain projects, a more systematic approach to deciding whether panels should review projects has been developed, using the following considerations:

a) cost;

b) complexity;

c) whether a new area of activity or discipline is involved;

d) whether ethical considerations are involved (e.g. studies involving human data, or experiments involving animals); and

e) whether a number of projects, which fall into a similar group or subject, would benefit overall from a panel review.

Experience has shown that significant effort is involved in setting up a review panel. This may lead to a delay in initiating a project.

Nevertheless, panels tend to improve the overall results of projects and increase the net benefit. Appendix A lists the title and membership of each panel.

Compared to the seven review panels in existence in FY 85/86 which oversaw ten active projects, there were thirteen review panels in FY 86/87 overseeing thirty-two active projects. At present, most project managers have one or two review panels to administer.

Generally speaking, the review panels seem to have provided a net benefit to the program. It is still too early, however, to do a more elaborate cost-benefit analysis of review panels on a project-by-project or panel-by-panel basis. Several panels have been set up to look at topical areas which may encompass more than one project. In other cases, new projects have been added to the purview of pre-existing panels in an effort to increase overall efficiency.

Beginning with this Annual Report, the impact of the review panels on the conduct and direction of the work being done by the contractor has been assessed and is included in the individual project descriptions (in Appendix B) under the subheading: Review Panel Activities. The more administrative matters involving review panels (number of meetings, correspondence, reviews, etc.) are dealt with according to each review panel, in Appendix A.

1.2.3 Post-Project Evaluation

The evaluation consists of six parts:

a) an evaluation of the contractor's performance;

b) a review of the actual use made of the results of the project;

c) an evaluation of the value of the work to and its effect on AECB activities;

d) an evaluation of any contribution to the general body of scientific knowledge (to begin with evaluations done in 1987-88);

e) an evaluation of the value of the work in relation to the cost ("value for money"); and

f) recommendations (if any) for further work or further action.

Parts a), b) and f) are the responsibility of an evaluator identified when the project is initiated. There may be more than one evaluator, and evaluators may be appointed from inside or outside the AECB. If a panel exists, it provides input to this part of the evaluation as well. Parts c), d), and e) are the responsibility of the Regulatory Research Branch.

For post-project evaluation, an initial questionnaire is completed within a few months of receipt by the AECB of the final report or other product according to the terms of the contract. If necessary, follow-up questionnaires are initiated until sufficient information has been collected to complete the evaluation and draw the necessary conclusions. A summary of the results and conclusions of each project, when completed and evaluated, is stored in the information retrieval system (MORIS) for future availability or analysis. For the purposes of the annual report, a project is considered to be completed when the initial post-project evaluation has been completed.

During the period, thirty-six post-project evaluations were completed.

1.2.4 Publications

A new feature introduced in the FY 86/87 Annual R & D Report is a listing of the open-literature publications (in addition to the AECB INFO-series publication) that resulted from individual projects (listed in Appendix B). Such publications may have been prepared by the contractor, by AECB staff, or jointly. Generally, only completed projects or very long-term projects will give rise to publications in the period year. These publications may include articles in refereed journals, presentations at conferences or seminars, contributions to review articles, and so forth. Since publications (other than the AECB INFO-series publication) often do not appear until several years after the submission of the final contract report to the AECB, the absence of a listing under the subheading "Publications" may only mean that it is too early after the receipt of the final report for a journal article to have appeared. Many private sector contractors do not write up their results for open-literature dissemination.

In order to prepare a cumulative list of all open-literature publications, the Regulatory Research Branch has requested all its present and previous contractors to provide a list of all publications prepared as a result of all contracts held with the AECB.

2. REVIEW BY MISSION OBJECT

In Appendix B, there are projects listed as being active, but for which there is no mention of results in the Mission Object overview. The results of these projects were reported in the previous R & D Annual Report but remained active because the post-project evaluation was not completed (84.1.19, 84.1.27, 84.1.28, 84.1.38, 84.1.39, 84.6.1, 85.3.3, 84.3.13, 85.3.7, 85.6.4, 84.8.9, 84.8.13).

MISSION OBJECT 1 - NUCLEAR REACTORS

There were thirty-three active projects in this Mission Object in FY 86/87, of which fourteen were completed during the year.

The active projects may be grouped into five groups.

(a) Component and system reliability:

Project 85.1.3 provided recommendations as to appropriate handling procedures that should be used by licensees to avoid degrading the reliability of new technology microcircuit systems during installation and maintenance activities.

Work dealing with nuclear power plant equipment qualification issues was initiated under projects 86.1.1 and 86.1.2. To date a review of Canadian and foreign regulatory requirements and industry standards has been completed (86.1.2), and a process for identifying which equipment should be qualified has been partially developed (86.1.1).

Aging degradation of various elastomeric components used in CANDU pressure boundary service was investigated in project 86.1.20; the completed work included a summary of the properties and aging characteristics of elastomers, and reviews of design requirements and specifications, regulatory requirements and industry standards, recommended procedures and actual practices for operation, monitoring and maintenance. Project 84.1.1 investigated factors affecting the permeability of containment concrete samples artificially aged either through freeze-thaw cycles or by the introduction of cracks. Preliminary results indicate that the permeability increases with cracking but does not change significantly with freeze-thaw cycling.

Experimental tests were performed under project 84.1.2 to determine the susceptibility of shut-off-rod guide tubes to deformation by shock waves generated by a postulated pressure tube rupture. Results to date indicate that the guide tubes are transparent to shock waves. Data on similar experiments involving calandria tubes are being analyzed. Project 85.1.6 showed that pump inlet piping geometry affects the pump vibration characteristics.

(b) Piping integrity

Project 85.1.9 investigated the accuracy and repeatability of the decibel drop-off ultrasonic methods in defect sizing; data which were collected are being analyzed. Risks associated with the ice plugging of large diameter ferritic pipes using liquid nitrogen were examined in project 86.1.13; pertinent information was reviewed and the final report is in preparation.

A series of small specimen tests was conducted under project 85.1.8 as part of an effort to develop a practical method for the analysis and assessment of stable crack propagation under elasto-plastic strain conditions. Results of project 84.1.4 indicate that the oxidizing behaviour and hydriding behaviour of Zr-2.5% Nb alloy are superior to that of Zircaloy; small quantities of metals such as iron, chromium and nickel in zirconium alloys give rise to higher hydrogen pick-up rates.

Under project 86.1.18 the AECB is participating in an International Piping Integrity Research Group, the goal of which is to develop a technical data base for use in assessing the fracture behaviour of large diameter piping.

(c) Computer-related projects

Project 84.1.17 provided technical background information on software quality assurance concepts for AECB staff involved in the writing of IAEA and CSA standards. Software configuration management methods are being surveyed in project 86.1.14.

Two projects involved "desktop simulation"; project 85.1.10 produced a computer simulation of the shutdown and regulating systems of the Darlington power reactor, and project 86.1.24 will acquire a simulation shell program for use in evaluating emergency operating procedures. The use of full scope control room simulators for effective training and testing of operators is being examined by project 85.1.7.

A series of tutorial lectures on the fundamentals of expert systems was prepared and given to AECB staff under project 86.1.25.

(d) Safety analysis

Under project 86.1.22 the thermohydraulic code CATHENA was adapted for the APOLLO 3000 microcomputer as a tool for assessing CANDU emergency core cooling system performance. The possibility of steam explosion due to molten fuel/moderator interaction (after a postulated pressure tube rupture) was indicated by project 84.1.30.

A microcomputer software package for assessing the effects of various correlations on heat transfer predictions is being developed under project 86.1.19. Project 85.1.11 confirmed the feasibility of using background vibration measurements to verify analytically derived natural frequencies and mode shapes of major seismically qualified plant equipment

Project 84.1.12 described what would constitute a good fire hazards analysis report and, in addition, provided a tutorial volume of background information on fire hazards analysis.

Project 86.1.15 is examining the airborne transport of radioactive materials near nuclear power plant buildings and flow visualization experiments are being performed. Project 84.1.19 produced recommendations as to what constitutes adequate meteorological information for effective safety analysis.

(e) Human factors:

Human factors issues in control room emergency operating procedures were examined in project 84.1.26 and criteria for evaluating such procedures were developed.

The expenditure in this Mission Object was $502K.

MISSION OBJECT 2 - HEAVY WATER PRODUCTION PLANTS

There were two active projects in this Mission Object in FY 86/87, one of which (85.2.1) was completed during the year. For both contracts all investigative work was completed in the previous year, requiring only delivery of the final reports in FY 86/87. No funds were expended in FY 86/87, the final reports being completed at contractors' expense.

Project 84.2.2 provided an examination of the flammability and detonability of hydrogen sulphide gas clouds, and concludes that there does not appear to be a significant chance of an unconfined vapour cloud explosion with hydrogen sulphide. Project 85.2.1 summarized and updated previous work on the probabilistic consequences following inadvertent releases of hydrogen sulphide gas from heavy water production plants.

The expenditure in this Mission Object was $0.

MISSION OBJECT 3 - URANIUM MINES AND MILLS

There were fourteen active projects in this Mission Object in FY 86/87, of which five were completed during the year.

The active projects fell into two broad groups.

(a) Airborne Radioactivity Studies

Project 85.3.10 was initiated in order to determine the fluxes of radon and thoron gases in a uranium mine in Ontario, while project 85.3.11 was begun, similarly, to determine the flux of radon gas in a uranium mine in Saskatchewan. There is no thorium present (and, therefore, no thoron gas) in the host ore of the uranium mine in Saskatchewan. By the end of FY 86/87, methodologies were being developed and measurements were being carried out at selected underground locations.

Another project (86.3.2) is concerned with the calibration of wire screen collectors used in the measurement of the unattached fractions of radon daughters and thoron daughters. Phase I of this project (a literature review) was completed, in FY 86/87, and Phase II was initiated. As of March 31, 1987, computer models to simulate the deposition of the unattached fractions of radon and thoron daughters on the wires of a mesh screen were being written and tested.

The objective of project 85.3.13 was to determine the physical characteristics (size distribution and radionuclide composition) of airborne uranium ore and yellowcake dust at a Saskatchewan mill. This study was an extension, to Saskatchewan, of a study conducted in mines and mills in Elliot Lake from 1982 to 1984. The preliminary results obtained from the measurements indicate that the physical dimensions of airborne radioactive dust are similar to those found in Elliot Lake facilities.

Project 84.3.22 was intended to develop a reliable dissolution process to determine the solubility rates of airborne radioactive aerosols found in the facilities at the front end of the fuel cycle. The results obtained in this project will be incorporated into the full-scale project entitled: Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities (85.3.6).

Project 86.3.4 was carried out in order to measure, in vivo, the body burden of Th-232 in mill workers who were exposed to thorium dust during the 1950s and 1960s. The preliminary results were that the levels of Th-232 measured in the three volunteers for this project were insignificantly different from background levels. As a result of these preliminary results, the project was terminated and no dose calculations were performed.

(b) Instrumentation

Project 86.3.6 involved the technical evaluation of an instant working level meter by CANMET (Department of Energy, Mines and Resources). Testing took place during a session of the NEA/CEC (Nuclear Energy Agency/Commission of the European Communities) International Intercalibration and Intercomparison

Program held at the U.S. Bureau of Mines laboratory in Denver, Colorado. It was also evaluated at the Canadian Radon-Thoron Calibration Facility (operated by CANMET) in Elliot Lake. Another project (86.3.5) involved the modification of a personal alpha dosimeter for use in uranium mines and mills in Canada. By the end of FY 86/87, modifications of the measuring head of the personal alpha dosimeter (to eliminate contamination in high-grade ore operations) had been made and were being field tested to assess the reduction in the contamination observed in earlier models.

Project 85.3.12 conducted a statistical analysis of the responses to a user's survey by uranium miners who were voluntary users of a helmet-type powered respirator. The contractor (AECL) found that use depended strongly on job category. However many of the factors (such as job description, experience, comfort, etc.) examined were use-dependent instead of use-determining, or had no effect on proper use.

The expenditure in this Mission Object was $167K.

MISSION OBJECT 4 - OTHER FUEL CYCLE FACILITIES

There were twelve active projects in this Mission Object of which seven were initiated in FY 86/87 and five continued from the previous year. The projects fall into the following groups.

(a) Environmental Pathways

Seven projects dealt with the migration of radionuclides in the food chain (84.4.3, 84.4.4, 84.4.10, 86.4.5, 86.4.6, 86.4.7 and 86.4.9). The radionuclide concentration factors derived in two projects indicate that the pathways feed/poultry/eggs (84.4.3) and forage/moose (84.4.10) do not seem to be important pathways in the calculation of doses arising from uranium mining and milling facilities in Canada. The study of diet pathways involving beaver and grouse which are specific to uranium mine, mill and tailings operations was recently initiated and sampling sites in the Elliot Lake (Serpent River basin) area have been selected. A recently completed survey (86.4.7) resulted in the establishment of a large Canadian data base on the radionuclide content of fish. These data indicate that while a good amount of information exists on uranium and radium-226, information on thorium is lacking. An extensive review on the radionuclide content of human milk (84.4.4) indicated the lack of useable information. As a result, a follow-up study (86.4.9) to develop analytical techniques and sampling methodologies for use in a field study is being undertaken. In an another project (86.4.6) it was found that adequate Canadian data were lacking for the validation of default values on soil to plant radionuclide concentration factors. Plans for a field study are currently being reviewed.

(b) Geology

There were five projects dealing with various aspects of geology. Neotectonics in Eastern Canada (86.4.2), was dropped, but its incorporation in the program represents the inception of the MAGNEC program (Multi-Agency Group for Neotectonics in Easter Canada). The remaining four all dealt, directly or indirectly, with trying to understand the nature and frequency of the instability of the earth's crust in various parts of eastern Canada.

One of the studies (84.4.1) is actually a geochronology study with the objective of determining the feasibility of using electron-spin resonance to directly and reliably date quartz in fault zones. The second (85.4.10), an on-going study, involves searching for geological evidence of seismicity in the Charlevoix, Québec area and the last two (85.4.14 and 86.4.1) were continuations of a program undertaken to measure ambient rock stress in a quarry with geologically young deformation structures. In the Charlevoix area sand volcanoes, believed to be seismically-induced, have been identified as have numerous faults in unconsolidated sediments. The origin of the faults is unknown. The stress-measurement work has thus far shown: a) pop-ups are normal to P-stress, and b) there is no obvious change in orientation of P from the Paleozoic to the Precambrian.

Project 86.4.8 reviewed the characteristics of suspended solids in liquid effluents from nuclear power plants, and collected information on related utility and regulatory practices in other countries. The results of the project indicate that the physico-chemical processes involved in suspended solid transfer and deposition are not yet completely understood.

The expenditure in this Mission Object was $210K.

MISSION OBJECT 5 - WASTE MANAGEMENT

There were twenty active projects in this Mission Object, six of which were completed.

The projects funded in this Mission Object fall into three groups:

(a) Uranium Mill Tailings

A study on the cost of decommissioning (84.5.1) showed that, for a generic, 40 hectare tailings facility, decommissioning costs are estimated to be in the range $2.5 to 3.75 million, and post-decommissioning costs are estimated to be in the order of $34,000 per year, for the first five years, and about $11,000 per year thereafter. The Phase 1 study dealing with the concentration of slimes (84.5.11) noted that there are definite problems resulting from concentration, whether the slimes are left at the surface or are emplaced underground. The outcome led to the Phase 2 study (86.5.1) the objective of which is to determine, or at least identify, methods for dealing with the problems attendant upon concentration. This study is not yet complete. Project 85.5.7 addressed the mechanics of sedimentation and remobilization of radionuclides and involved laboratory measurements to verify computer model estimates of processes responsible for radionuclide transport from sediments to water. A study on the optimization in decommissioning (85.5.9) provided a tutorial on the determination of methods for decommissioning tailings along with their associated costs. A study on the ecological dynamics of tailings (84.5.17) underscored the complexity of evaluating radionuclide transfer, in the long-term, from tailings through vegetation.

(b) Shallow Ground Disposal

Seven projects dealt with low-level wastes; one reviewed the performance of engineered barriers (86.5.3), the second dealt with the methodology for estimating probabilities of intrusion (86.5.4) and a third addressed erosion of surface and near-surface disposal (86.5.7). The results of all three of these studies pointed out deficiencies in either data or in state-of-the-art approaches, illustrating the need for further attention to these aspects of shallow ground disposal.

Four projects in this shallow disposal category were specifically related to computer modelling. An evaluation was made of the PRESTO-CPG model for low-level wastes in shallow land burial facilities (84.5.15). It was concluded that using a probabilistic version of the PRESTON-CPG model for shallow nuclear waste disposal facilities would not be feasible due to the limited speed of the AECB HP-1000 computer system. The FEMWATER/FEMWASTE flow and contaminant transport model was installed on the AECB's HP-1000 computer to allow examination of available codes on contaminant transport (85.5.3). This installation was made with great difficulty because of technical limitations in the memory management system. A survey was made of verification and validation methods for waste disposal models (85.5.8) and the development of plotting routine for the FEMWATER/FEMWASTE model (86.5.8) was initiated.

(c) Deep Disposal

There were six projects in this category. The impact of radiation on containment was examined and produced information of relevance in a hydrogeology, pointing out that the greatest effect would be to lead to the development of fractures, thereby facilitating groundwater flow (84.5.5). The influence of vertical crustal movements on ground-water flows (84.5.9), a review of subsurface hydrogeological conditions (84.5.13), the hydrological factors to be addressed in site evaluation (84.5.14), and the influence of state-of-stress on ground water flow (86.5.2) provided information of use in the development of regulatory guidelines and indications of areas in which further work could be carried out.

In another project (86.5.9) the concept of deep geological disposal of radioactive waste is being evaluated with a view to determining the parameters to which the predicted performance of the concept would be most sensitive.

(d) Miscellaneous

Project 85.5.1 provided a global review of the current and proposed methods for estimating the radionuclide content of waste packages. The study also proposed rational approaches for the subdivision of current methods. Two other projects "Verification, Validation and QA for Waste Disposal Models" (85.5.8) and "Plotting for a Groundwater Flow/Containment Transport Model" (86.5.8) were initiated.

The expenditure in this Mission Object was $409K.

MISSION OBJECT 6 - NON-FUEL CYCLE APPLICATIONS

There were ten active projects in this Mission Object, of which five were completed. The projects funded in this Mission Object fell into two groups:

(a) Development and Evaluation of Instrumentation and Procedures for Field and Laboratory Use

Significant progress has been made on the development of a personal neutron dosimeter based on a new "bubble-damage polymer" technology (projects 85.6.1 and 86.6.1). This dosimeter should provide, to a spectrum of AECB licensees working in diverse environments, greater confidence in their evaluations of individual neutron doses. An independent evaluation of the Berthold LB1200 survey meter was carried out (85.6.3) to investigate the capabilities and limitations of this device when used in conditions encountered in the field. This survey meter is used extensively by the staff of the Compliance Services and Laboratories Division (CSLD). To assist CSLD staff in monitoring compliance with the licence conditions that require leak testing of sealed radiation sources, the preparation of a technical reference document was commissioned which identified suitable techniques of "wipe" analysis and described a kit for quantitatively checking the accuracy of the wipe test procedures used by licensees (86.6.6).

The CSLD requested two projects to increase the capability of the laboratory to analyze samples submitted for evaluation (86.6.3, 86.6.5). The routine use of the instrumentation and procedures developed is expected to impact significantly on laboratory efficiency.

The CSLD also requested a project to produce a reference document that evaluates methods and procedures used for calibrating radiation survey meters with reference to the current AEC Regulations (86.6.7). This document will assist CSLD inspectors to conduct consistent and effective evaluations of survey meter calibrations.

(b) Dose Assessment

Two studies were commissioned to provide information pertaining to the necessity for personal dosimetry for users of two classes of industrial radiography equipment: well-logging equipment and portable moisture-density gauges (84.6.8, 86.6.2).

In project 84.6.8, the contractors determined that, in oil-well logging operations, workers often received monthly doses in the range 30 μSv (as determined by CR-39 detectors) to 200 μSv (the lower level of detectability of the NTA dosimeters). These doses are small compared with those received by many Atomic Radiation Workers in other industries involving radioactive prescribed substances.

Preliminary results arising from project 86.6.2 showed that significant neutron doses may be encountered by workers during the maintenance of portable moisture-density gauges.

Following the ICRP recommendation to double the value of the neutron quality factor, the AECB commissioned a study (85.6.4) of the physical and biological basis for the neutron quality factor. The contractor concluded that there was not sufficient justification for doubling the value of the quality factor.

Project 84.6.4 developed a training manual for prospective qualified operators, in Canada, on the procedures to be followed for working safely with gamma radiography equipment. This manual will be used as a reference document for the certification examination for AECB qualified operators. The manual will be published in both Official Languages.

The expenditure in this Mission Object was $173K.

MISSION OBJECT 7 - TRANSPORTATION

There were two active projects in this Mission Object in FY 86/87. The first of these projects (85.7.1) dealt with an investigation of the behaviour of impact limiting fins on containers for transporting radioactive materials, when such containers undergo collisons. The study provided information on the behaviour of fins made of stainless steel as compared to that of fins made of mild steel. This information will be considered in writing guidelines for the construction of containers.

Project 86.7.1, which was ongoing at the end of FY 86/87, investigates the doses received by road transport workers who handle packages and containers of radioactive materials. The findings of this project will identify problem areas in the road transportation industry and thereby suggest any necessary improvements or regulatory action.

The expenditure in this Mission Object was $35K.

MISSION OBJECT 8 - HEALTH PHYSICS

There were thirty-seven active projects in the Mission Object in FY 86/87, of which three were completed. For the purpose of this report, the projects in this Mission Object are divided into four groups:

a) epidemiology and record-linkage;
b) radiobiology;
c) biological dosimetry; and
d) reactor effluent control technologies.

(a) Epidemiology and Record-Linkage

Nineteen projects are included in these groups. Twelve projects were initiated during FY 86/87, with the remainder having begun in prior years. Several projects in these groups were jointly supported by other government departments and agencies, such as National Health and Welfare, Statistics Canada and Atomic Energy of Canada Limited.

Ten projects dealt with the mortality or morbidity statistics for Ontario and Saskatchewan uranium miners and Newfoundland fluorspar miners, or for mining communities (84.8.4, 84.8.5, 84.8.6, 85.8.21, 86.8.9, 84.8.7, 85.8.6, 84.8.10, 85.8.16, 86.8.18). The most significant epidemiological studies were those dealing with the mortality of Ontario uranium miners (84.8.4, 86.8.18) and St. Lawrence fluorspar miners (84.8.5). The preliminary results from both of these studies confirm that the risk estimates for lung cancer owing to radon daughter exposures are not significantly different from the values currently recognized as valid by the AECB. The preliminary results of other studies (84.8.6, 85.8.21, 85.8.6) appear to give further guidance for improving future follow-up epidemiological studies, and for the choice of an appropriate model for estimating lifetime risk of radiation induced cancers (86.8.9).

Project 84.8.10 is a long-term and continuing epidemiological study of cancer mortality among some 300,000 Canadians occupationally exposed to low levels of ionizing radiation. The study is intended to develop suitable linkages between the Canadian National Dose Registry (NDR) and the Canadian Mortality Data Base. Funding has also been provided by the Department of National Health and Welfare and Statistics Canada. The following preliminary results have been obtained: matching the Social Insurance Number (SIN) to the National Dose Registry; performing numeric linkage resolutions; merging results of numeric linkages to complete the Master Identification File; adding corrections to the Master Identification File; collapsing the records and filling in data; adding AECL records to the NDR; testing the NYSIIS (name encoding scheme) internal linkage and death linkage; and creating an analysis file.

As an initial requirement of project 85.8.16, the contractor has developed a detailed and comprehensive employee identification form and a set of accompanying explanatory notes. The contractor is now pre-testing this form on several companies to assess its effectiveness as a standard employee identification form.

Also included in group (a) are four studies of childhood cancers, and developmental and genetic disorders in both children and adults who received radiation exposure during childhood, or whose parents were exposed to ionizing radiation under a variety of conditions (85.8.4., 85.8.7, 84.8.1, 85.8.18). The results of the study of childhood genetic disorders (84.8.1) indicate a lower value for the percentage of genetic abnormalities among children, in comparison with the values reported by other national and international studies. It is hoped that when the final results of the follow-up study on adults (85.8.18) are available, the AECB will be in a position to make a comprehensive estimate of the risks of lifetime genetic disorders due to ionizing radiation. Preliminary results of two other feasibility studies (85.8.4, 85.8.7) appear to identify a number of difficulties in ascertaining the appropriate end point, with regard to childhood disorders, and in the estimation of past medical exposures.

The epidemiological study of thyroid cancer (86.8.15) is to be jointly supported by all ten provincial cancer registries and the Department of National Health and Welfare. The contract is expected to begin in FY 87/88.

Three additional studies (84.8.2, 84.8.12, 86.8.17) investigated the distribution of risk of non-radiological occupational activities and the willingness of Canadian industries and society to reduce risk in work and domestic environments. In project 84.8.2, five case studies were selected for detailed analysis. These studies revealed a wide range in the definitions of risk and therefore expenditure per unit of risk reduction. The report concluded that there was no one measure of spending for risk reduction but a spectrum of such measures. Further attempts to quantify these estimates should be restricted to cases where confounding factors are minimized or absent. Project 84.8.12 and the supplementary study, 86.8.17, presented information on non-radiological risk distributions for Ontario-based industries. These data will permit comparisons (by the AECB) with radiological risk distributions, for Ontario-based industries.

Project 85.8.3 was undertaken to investigate the rationales or bases for the current occupational exposure limits for ten hazardous chemical substances found in Canadian industry and to compare these with the basis for occupational exposure limits for ionizing radiation. Each chemical was discussed under the headings of physiological intake and elimination in humans, characteristics of acute and chronic toxicity, sites of occupational exposure and rationale for limits for such exposures. The report concluded that exposure limits for ionizing radiation are sufficiently low to remove the appearance of directly related injury. It is expected, however, that low-level exposure may have a stochastic effect, that is, there is the possibility of a slightly increased incidence of neoplasms in a large exposed population, but numbers will be too small to be able to attribute any particular case to the exposure. Threshold Limit Values (TLVs) which are the concentration limits for hazardous chemical substances, may be high enough to result in some directly-related health detriment or symptoms in the exposed individual.

(b) Radiobiology

Seven projects were included in this group (84.8.8, 84.8.11, 84.8.14, 84.8.15, 85.8.13, 85.8.20, 86.8.19). Project 84.8.15 is jointly funded by the AECB, AECL, and the public utilities (Ontario Hydro, Hydro Quebec, and NBEPC). Project 85.8.20 is jointly funded by the AECB and AECL, while 86.8.19 is a jointly-funded venture of Ontario Hydro and the AECB.

Of the seven projects, four (84.8.11, 84.8.15, 85.8.13, and 86.8.19) are multi-year laboratory experiments on rodents to investigate the radiobiological significance of exposure to tritium, to uranium ore dust, and to external X-ray radiation.

Project 84.8.11 is concerned with the health effects of inhaled uranium ore dust, in order to determine the carcinogenicity of this dust. The aim of Phase I of project 84.8.11 is to generate airborne uranium ore dust of the appropriate size distribution and concentration. A supply of high-grade ore was secured; the dust generation system and on-line (size distribution) monitoring equipment are being tested. The review panel was consulted in order to finalize the experimental protocol, most specifically in regard to the strain of animal to be used, the determination of exposure conditions for the main study and the need for a preliminary study aimed at ensuring that the animals would be able to withstand actual exposure conditions. The contractors, in consultation with the review panel, carried out an evaluation of the parameters, which would be needed to interpret the final results of the main study.

The measurement of the thickness of the human bronchial epithelium is the subject of project 84.8.14. For this continuing project, lung sections from twenty surgical cases, to date, have been prepared and fixed in methacrylate. Measurements have begun of bronchial size, epithelial thickness, number of basal cells per bronchus, and other parameters required for the assessment of cells at risk from inhalation of radioisotopes, and cancerous cell development and type. Projects 84.8.15 and 86.8.19 both deal with the health effects of tritium: the first with the measurement of the relative biological effectiveness (RBE) for tritium for the induction of myeloid leukemia and the second with cytogenetic measurements of the RBE for tritium. For project 84.8.15, the contractors (AECL) have established the necessary breeding colony of mice. Irradiations are underway using highly-filtered 150kVp X-rays, while injections of tritiated water have also been initiated. For project 86.8.19, three radiation doses have been selected and are being administered for both the spermatocyte and lymphocyte studies (using the same irradiation facilities and strain of mice as in 84.8.15).

Project 85.8.20 deals with the screening of human populations for abnormal radiosensitivity. In this project the contractors (AECL) have developed, as a first step, a "grow-back" procedure for assessing the relative detriment occasioned by a given radiation exposure.

The results of project 84.8.8 (a feasibility study) suggested a full-scale study on rats and monkeys, using 2-dioxyglucose as a biochemical tracer to quantify the activity of different parts of the brain as a function of in utero exposure to ionizing radiation and of the stage of gestation (85.8.13).

(c) Dosimetry

Seven projects were being carried out in this group (84.8.18, 85.8.2, 85.8.8, 85.8.15, 86.8.20, 86.8.21, and 86.8.22). These projects are designed to improve the accuracy of present and past exposure or dose estimates at the workplace.

Project 84.8.18 was concerned with the measurement of the distribution of radiation doses to nuclear medicine technologists in the course of their work during diagnostic imaging procedures. Comparison of the doses to technologists inferred from procedural measurements with the time co-incident collective dose equivalent recorded by the TLD service of the Bureau of Radiation and Medical Devices indicated that approximately half of the collective exposure, received by technologists, arose from patient handling and one specific diagnostic procedure.

Project 85.8.8 was aimed at assessing and comparing the uncertainties attached to the doses received by uranium workers before systematic individual dose monitoring was initiated.

In Project 85.8.2, the growth of submicron aerosols in a simulated respiratory tract was studied. Preliminary results indicated that the aerodynamic diameter of NaCl and kerosene combustion aerosols grow by a factor of 1.9 and 1.3, respectively, when relative humidity increases from 35% to 100% and temperature increases from 20°C to 37°C. The results will be used to determine to what extent indications given by current dosimetric lung models could be affected by aerosol growth within the human respiratory tract.

The objective of project 86.8.21 is to assemble a comprehensive list of the data on uranium intake, organ burden, retention and excretion, with which current biokinetic and dosimetric models for uranium predict doses to individuals. (The contract is expected to begin in FY 87/88.)

The objective of project 86.8.20 was to investigate whether measurements made with hand-held radiation contamination monitors (RCMs) and gamma survey meters (GSMs) can provide AECB licensees with convenient means of obtaining reliable quantitative estimates of thyroid burdens carried by their employees. AECB licensees generally possess RCMs and GSMs, but many licensees do not have access to routine thyroid monitoring facilities.

For project 85.8.15, the contractor has assembled a list of non-radiological carcinogenic substances in use at various nuclear facilities in Canada. Efforts are underway to determine whether existing measurement regimes can provide adequate information on the health effects of these non-radiological substances to workers at those facilities.

Project 86.8.22 is a literature review on the uptake and retention of radionuclides by the fetus. The findings have shown that more experimental work is needed to permit accurate estimation of dose to the fetus following intake of radionuclides such as uranium, thorium, and their long-lived daughter products.

(d) Reactor Effluent Control Technologies

Project 85.8.11 examined the cost-effectiveness of various methods of reduction of off-site dose at nuclear power plants.

The expenditure in this Mission Object was $896K.

MISSION OBJECT 9 - REGULATIONS & REGULATORY PROCESS DEVELOPMENT

There were four active projects in this Mission Object, two of which were completed (84.9.3 and 86.9.1).

The final report for project 84.9.3 on the methodologies for the evaluation of AECB Regulatory Programs contains a bibliography consisting of 280 abstracts assembled from an extensive search of the international literature. Each cited publication describes or uses methods applicable to the evaluation of regulatory programs. The report reviews the methodologies found in the literature, identifying the most relevant references for each step in program evaluation. It examines the applicability, the advantages and disadvantages of the different evaluation methods, and makes recommendations about the selection of methods and their application to the AECB regulatory programs.

The Uranium Mine Radiation Safety Course (UMRSC) (86.9.1) was conducted again (in two sessions, involving 34 participants) by the Canadian Institute for Radiation Safety (CAIRS).

CAIRS also began the development of a radiation safety training module for use in Canadian uranium and thorium mines (86.9.2). Several pilot runs of the training module have been conducted by the contractor, in classroom settings, in Saskatoon and in Elliot Lake.

Project 85.9.2 to collect information for the Socio-Economic Analysis of Proposed General Amendments to AEC Regulations was begun. In this fiscal year the contractor was occupied with assembling the basic information, through questionnaires and interviews, on the anticipated costs and benefits to licensees, of the proposed amendments. The schedule for completion of the project was put back to 1987 October to allow several licensees more time to complete questionnaires.

The expenditure in this Mission Object was $200K.

MISSION OBJECT 10 - SECURITY

There were no active projects in this Mission Object.

The expenditure in this Mission Object was $0K.

Table 1: Regulatory R & D Expenditures for FY 86/87
(FY 86/87 Budget Allocation: $2,993,000)

MISSION OBJECT	ACTUAL EXPENDITURES $	INITIAL PLAN $
1. Nuclear Reactors	501,502	1,044,000
2. Heavy Water Production Plants	NIL	NIL
3. Uranium Mines and Mills	167,331	292,000
4. Other Fuel Cycle Facilities	209,517	395,000
5. Waste Management	409,375	472,000
6. Non Fuel Cycle Applications	172,875	140,000
7. Transportation	35,300	84,000
8. Health Physics	896,358	1,271,000
9. Regulations and Regulatory Process Development	200,333	223,000
10. Security	NIL	NIL
CONTRACTS TOTAL:	2,592,591	3,921,000
DSS SERVICE CHARGES:	79,591	
REVIEW PANELS:	50,194	
WORKSHOPS:	12,000	
UMRSC STAFF TRAVEL:	19,196	
TOTAL PROGRAM EXPENDITURES:	2,753,572	
WORKING BUDGET:	2,993,000	
AMOUNT SPENT ON THE PROGRAM:	2,753,572	
AMOUNT UNSPENT OR USED FOR OTHER PURPOSES:	239,428	

APPENDIX A

Review Panels: Membership and Activities

(In this appendix, review panels are designated "H" for "Health Effects" and "S" for "Safety".)

APPENDIX A

Review Panels: Membership and Activities

H1 RADIATION-INDUCED DEVELOPMENTAL DEFECTS - V. Elaguppillai

Project Number	Project Title
84.8.8	Study of Health Effects on Central Nervous Systems following In Utero Exposure to Ionizing Radiation
85.8.13	Full-Scale Study of Health Effects on Central Nervous System following In-Utero Exposure
85.8.7	Epidemiological Study of Radiation-Induced Developmental Defects among Canadians
85.8.22	In Vitro and In Vivo Studies of the Ionizing Radiation on the Developing Central Nervous System

Review Panel Membership

Dr. L.E. Becker, University of Toronto
Dr. T.V.N. Persaud, University of Manitoba*
Dr. P. Rakic, Yale University
Dr. J. Muller, Ontario Ministry of Labour
Dr. W.J. Schull, University of Texas Health Sciences Centre
Dr. D.K. Myers, Atomic Energy of Canada Limited

Review Panel Activities

The review panel met three times during the year and was asked to comment on the progress report(s) for project 84.8.8, and to review the work statements for projects 85.8.7 and 85.8.13.

*Panel member for all projects except 85.8.22

H2 EPIDEMIOLOGY - V. Elaguppillai

Project Number	Project Title
86.8.9	Adequacy of Relative and Absolute Risk Models for Lifetime Risk Estimates of Radiation-Induced Cancers
84.8.13	Epidemiological Study of Thyroid Cancer from I-131 Exposure
85.8.4	Epidemiological Study of Childhood Cancers Due to Parental Irradiation
86.8.4	Study of the Health Effects of Low-Level Exposure to Environmental Radiation in Port Hope
86.8.12	Selection of Control Groups for Use in Epidemiological Study of Radiation-Induced Health Effects
86.8.15	Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure

Review Panel Membership

Dr. S. Buehler, St. John's General Hospital
Dr. D.H. Thomson, N.S. Cancer Treatment & Research Foundation
Ms. D. Robson, Saskatchewan Cancer Foundation
Dr. G. Theriault, McGill University
Dr. N. Kreiger, Ontario Cancer Treatment & Research Foundation
Dr. J.C. Wallace, Saint John General Hospital
Dr. G.B. Hill, Alberta Cancer Board
Dr. L. Marret, Ontario Cancer Treatment & Research Foundation
Dr. G. Howe, National Cancer Institute of Canada
Ms. M. McBride, Cancer Control Agency of B.C.

Review Panel Activities

The review panel met four times during the year and was asked to comment on the progress reports for projects 86.8.9 and 85.8.4, and to review the work statements for projects 85.8.4 and 86.8.15.

H3 INHALATION STUDIES - P.J. Duport

Project Number	Project Title
84.8.11	Study of the Health Effects of Inhaled Uranium Ore Dust

Review Panel Membership

Dr. J. Muller, Ontario Ministry of Labour
Dr. J. Lafuma, Centre d'Études Nucléaires de Fontenay-aux-Roses
Dr. J. Chameaud, COGEMA
Dr. D.H. Bowden, University of Manitoba
Dr. L.D. Brown, Saskatchewan Department of Labour
Dr. A.C. James, National Radiological Protection Board
Dr. R. Masse, Centre d'Études Nucléaires de Fontenay-aux-Roses
Dr. V. Elaguppillai, Atomic Energy Control Board
Mr. F. Horvath, Atomic Energy Control Board
Mr. C. Pomroy, Atomic Energy Cobtrol Board
Dr. Y. Mao, Health and Welfare Canada
Dr. B.L. Tracy, Health and Welfare Canada
Dr. M.E. Wrenn, University of Utah

Review Panel Activities

The review panel met twice during the year and was asked to comment on the progress report(s) for project 84.8.11.

H4 LUNG SOLUBILITY STUDIES - K.P. Ho

Project Number	Project Title
84.3.22	Feasibility Study of the Dissolution Rates of Uranium Ore Dust, Uranium Concentrates and Uranium Compounds in Simulated Lung Fluid
85.3.6	Physical Characteristics and Solubility of Airborne Long-Lived Dust in Uranium Producing and Manufacturing Facilities

Review Panel Membership

Dr. J.R. Johnson, Atomic Energy of Canada Limited
Mr. J. Tai-Pow, Ontario Ministry of Labour
Dr. M.L. Zamora, Health and Welfare Canada
Mr. F. Horvath, Atomic Energy Control Board

Review Panel Activities

The review panel met twice during the year and was asked to comment on the progress report(s) for projects 84.3.22, and to review the work statement for project 85.3.6.

H5 RELATIVE BIOLOGICAL EFFECTIVENESS - E. Rabin

Project Number	Project Title
86.8.19	Cytogenetic Measurements of the Relative Biological Effectiveness of Tritium
84.8.15	Measurement of RBE for Tritium for Myeloid Leukemia

Review Panel Membership

Mr. J. Baltar, Hydro Quebec
Dr. G.R. Douglas, Health and Welfare Canada*
Mr. J.U. Burnham, N.B. Electric Power Commission
Dr. K.Y. Wong, Canadian Fusion Fuels Technology Project
Dr. D. Whillans, Ontario Hydro
Dr. A.L. Carsten, Brookhaven National Laboratory
Mr. C. Pomroy, Atomic Energy Control Board

Review Panel Activities

The review panel met once during the year and was asked to comment on the progress reports for the above project.

*Panel member for project 86.8.19 only.

H6 RADIOSENSITIVITY OF BIOLOGICAL SYSTEMS - E. Rabin

Project Number	Project Title
85.8.20	Screening of Human Populations for Abnormal Radiosensitivity

Review Panel Membership

Dr. O. Kamra, Dalhousie University
Dr. M.C. Paterson, Cross Cancer Institute
Dr. M.W. McBurney, University of Ottawa
Dr. S. Raman, University of Ottawa

Review Panel Activities

The review panel met twice during the year and was asked to comment on the progress report(s) for project 85.8.20.

H7 BRONCHIAL EPITHELIUM - E. Rabin

Project Number	Project Title
84.8.14	Measurement of the Thickness of Bronchial Epithelium

Review Panel Membership

Dr. I. Dardick, Ottawa Civic Hospital
Dr. B. Case, Royal Victoria Hospital
Dr. R. Narbaitz, University of Ottawa
Dr. J.R. Johnson, Atomic Energy of Canada Limited
Dr. D.K. Myers, Atomic Energy of Canada Limited*
Mr. C. Pomroy, Atomic Energy Control Board

Review Panel Activities

The review panel met twice during the year and was asked to comment on the progress report(s) for project 84.8.14.

*Alternate panel member to Dr. J.R. Johnson.

H8 REGULATORY IMPACT ANALYSIS - C. St-Arneault

Project Number	Project Title
85.9.2	Socio-Economic Impact Analysis of Proposed General Amendments to Atomic Energy Control Regulations

Review Panel Membership

For this project, the review panel consists of the AECB senior management formed into a Senior Review Group (SRG).

J.W. Beare
Z. Domaratzki
W.D. Smythe

Review Panel Activities

The SRG participated actively in the review of the proposed work statement and in the assessment of the bids in response to the request for proposal. Members of SRG have also participated in five meetings with the contractor since the beginning of the contract.

S1 HYDROGEOLOGY - J.L. Wallach

Project Number	Project Title
84.5.13	A Review of Subsurface Hydrogeological Conditions
84.5.14	Hydrogeological Factors To Be Addressed in Guidelines
86.5.2	State-of-Stress and Groundwater Flow

Review Panel Membership

Dr. M. Sklash, University of Windsor
Mr. D. Lennox, Environment Canada

Review Panel Activities

No meetings were held. Panel members reviewed work statements, drafts and draft final reports for project 84.5.13 and 84.5.14. Responses to their comments were incorporated in final reports. No reports have yet been submitted for 86.5.2.

S2 GEOLOGY - J.L. Wallach

Project Number	Project Title
84.4.1	Determination of the Feasibility of Directly Dating Quart
85.4.10	Geological Evidence of Seismicity
85.4.14	Stress Measurements in Eastern Ontario - Phase II
86.4.1	Stress Measurements in Southern Ontario - Phase 3

Review Panel Membership

Dr. H. Helmstaedt, Queen's University
Dr. H. Schwarcz, McMaster University
Mr. D.A. Forsyth, Geological Survey of Canada

Review Panel Activities

None in this area. No reports have been received for review. All projects were in place before this panel was formed.

S3 ENVIRONMENTAL PATHWAYS - M.R. Avadhanula

Project Number	Project Title
84.4.4	Transfer of Radionuclides from Food to Human Milk - A Review
84.4.10	Determination of Concentration Factors - Game Animals
84.4.17	Transfer of Radionuclides from Food to Human Milk
86.4.5	Transfer Parameters - Non-Domesticated Animals
86.4.6	Effect of Soil on Radionuclides in Plants: Literature Survey
86.4.9	Transfer of Radionuclides to Human Milk - Phase 2 Feasibility

Review Panel Membership

Mr. J. Tai-Pow, Ontario Ministry of Labour
Dr. P. Colgan, Queens University
Dr. R.M. Chatterjee, Atomic Energy Control Board
Mr. J. Mes, Health and Welfare Canada*
Dr. D. Kinloch, Health and Welfare Canada*

Review Panel Activities

The review panel met once during the year to review the final results presented in debriefing seminars of projects 84.4.10 and 86.4.6.

*Panel member for only projects 84.4.4 and 84.4.17.

S4 SOFTWARE RELIABILITY - D.E. Connelly

Project Number	Project Title
84.1.20	A Tool to Analyze Real-Time Programs
86.1.14	Survey of Software Configuration Control Methods
84.5.15	Shallow Ground Disposal - Calculation of Dose
85.5.8	Verification, Validation and QA for Waste Disposal Models

Review Panel Membership

Dr. J.W. Chinneck, Carleton University
Dr. E.A. Sudicky, University of Waterloo

Review Panel Activities

None (the panel was only organized in late March 1987).

S5 OFF-SITE DOSE - D.J. Martin

Project Number	Project Title
85.8.11	Cost-Effectiveness of Reduction of Off-Site Dose

Review Panel Membership

Mr. G. Gunter, New Brunswick Electric Power Company
Mr. K.J. Donnelly, Ontario Hydro
Mr. A. Natalizio, Atomic Energy of Canada Limited
Mr. P. Finlay, Environment Canada
Dr. M. Bewers, Fisheries & Oceans Canada
Mr. W.R. Bush, Atomic Energy Control Board
Dr. R.M. Chatterjee, Atomic Energy Control Board

Review Panel Activities

The panel did not meet during the reporting period. Instead, correspondence was exchanged regarding the scope and direction of the project.

APPENDIX B

Project Summaries

1. The description of each project has been left as originally worded in the proposal, i.e., the future tense appears.

2. "**" in the title line indicates a project for which funds were first committed in FY 86/87.

3. The name of the principle investigator is in brackets following the name of the contractor.

4. In this appendix, review panels are designated "H" for "Health Effects" and "S" for "Safety". For the sub-heading Review Panel Activities, a blank implies that there is no review panel. If a review panel existed but there was no activity in FY 86/87, only the review panel number is given.

5. The published research reports are usually available through the AECB Office of Public Information and are identified by an "INFO" series number. This number and the title appear under "Publications".

MISSION OBJECT 1 - NUCLEAR REACTORS

84.1.1 The Permeability of Containment Concrete for CANDU Reactors

Category - 1* File Number: 34-2-4-25
Contractor - University of Toronto (Prof. R.H. Mills)
Toronto, Ontario

It is proposed to continue the experimental program which was started in FY 83/84 to investigate factors affecting the permeability of concrete samples artificially aged through freeze-thaw cycles. An attempt will be made to correlate any changes in permeability with initial conditions of internal cracking.

Previous, specially-prepared, small-scale samples showed very low permeabilities close to those of hard, sound rocks. The present program is, therefore, performed to identify whether the high permeabilities observed in some field structures are due to inherent construction defects and/or the aging process of the concrete.

The results of the study would provide information on whether laboratory techniques can be used to simulate leakage as reported from actual containment structure leakage tests and on whether leakage can be expected to increase with aging.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$95,000.00	0.00	$0.00	$95,000.00
Actual Spending:	$94,714.99	$0.00	$0.00	$94,714.99

Contract Completed: Yes

COMMENTS:

RESULTS: Permeability tests were performed on four concrete cylinders, 0.25 m in diameter and 2 m long, modelling the wall-thickness of reactor containment structure of a reactor. Tests were performed on the cylinders, before and after artificial longitudinal local cracks were induced. Using a longitudinal arrangement of pressure transducers and a computer controlled data acquisition system, quasi-permeability coefficients of the concrete were obtained. These coefficients were then used to characterize the concrete barrier. It was found that permeability increased greatly with the introduction of the cracks, and was affected by moisture content and casting direction. The effect of reinforcing steel on permeability could not be resolved within the bounds of experimental variables.

EVALUATION: Post Project Evaluation initiated.

PUBLICATIONS: INFO 1088-2, "Gas and Water Permeability of Concrete for Reactor Buildings - Prototype Scale Specimens".

REVIEW PANEL ACTIVITIES:

84.1.2 Shut-Off-Rod Guide Tube Susceptibility to Deformation

Category - 1* File Number: 34-2-4-30
Contractor - University of British Columbia (Prof. E.G. Hauptmann)
Vancouver, B.C.

It is proposed to carry out special-effect experimental tests and to perform computer-aided analyses to determine the susceptibility of shut-off-rod guide tubes and calandria tubes to deformation due to the generation and propagation of shock and pressure waves.

The proposed work will be carried out in an attempt to determine whether shut-off-rod guide tubes are transparent to shock waves generated in a hypothetical pressure-tube rupture event.

The results of the program will be used to assess licensee assumptions regarding the capability of the shutdown system to operate effectively under pressure tube rupture conditions.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$28,000.00	0.00	$0.00	$28,000.00
Actual Spending:	$27,980.00	$0.00	$0.00 (Estimate)	$27,980.00 (Estimate)

Contract Completed: No

COMMENTS: The experimental program was conducted satisfactorily. However, further discussion is underway on how the analysis and interpretation of the behaviour of the calandria tubes will be presented in the final report.

RESULTS:

EVALUATION:

PUBLICATIONS: E.G. Hauptmann et al., "Shock Wave Effects on Shut-off-rod Guide Tubes", Winter Annual Meeting of ASME, Miami Beach, Florida, Nov. 17-22, 1985.

REVIEW PANEL ACTIVITIES:

84.1.4 The Degradation of Zirconium Alloys in Nuclear Reactors

Category - 1* File Number: 34-2-6-5
Contractor - Westinghouse Canada Inc. (Dr. D. Lim)
Hamilton, Ontario

It is proposed to continue the critical review which was started in FY 84/85 to identify the degradation mechanisms of zirconium alloys in CANDU reactor environments. The review includes information on the long-term effects of, at least, corrosion, irradiation, hydridization and creep. The study is being carried out on relevant literature from non-Canadian sources and will highlight practical, remedial or preventative actions.

This work was undertaken to obtain an independent, critical review of non-Canadian information on the behaviour of zirconium alloys in a nuclear reactor environment.

The findings of this review and the information collected on the inspection of CANDU Zr-Nb tubes will be used to determine the safe service life of pressure tubes in CANDUs.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$37,000.00	0.00	$0.00	$37,000.00
Actual Spending:	$37,487.21	$0.00	$0.00	$37,487.21

Contract Completed: Yes

COMMENTS:

RESULTS: Much of the surveyed literature addressed the Zircaloys particularly in regard to their use as fuel cladding in a radioactive and oxidizing environment. The survey confirmed the understanding that hydriding in Zircaloys is mainly attributed to the process of surface oxidation in which the oxygen in the coolant (D_2O) oxidizes the metal at its interface with the oxide layer, while the hydrogen is absorbed by, and diffused into, the metal causing hydridization (D_2). For Zr-Nb alloys, the reviewed literature did not lead to concrete conclusions as to whether a potential exists for: i) accelerated hydriding due to corrosion at crevices and/or at second-phase particles, or ii) "breakaway" in oxidation and hydrogen acquisition in the long term. Specific information on U.S.S.R. power reactor experience could not be obtained.

EVALUATION: All tasks were completed and objectives met. The contractor who had a scientific grasp of the subject and an understanding of specialized areas, and had access to suitable data banks. The final report represents an information document which shows worldwide understanding of zirconium alloy behaviour in nuclear reactors. The conclusions of the report showed that AECB activities concerning pressure tube periodic, in-service and special inspections and analysis programs are consistent with international practice.

PUBLICATIONS:

1) INFO 0174, "The Degradation of Zirconium Alloys in Nuclear Reactors - A Review".

2) D.O. Northwood and D.T. Lim, "Corrosion and Hydriding of Zirconium Alloys in Nuclear Power Reactor Coolants", to be presented at the 5th Asian Pacific Corrosion Control Conference, Australia, November 1987.

REVIEW PANEL ACTIVITIES:

84.1.6 Instrument Behaviour under Off-Normal Conditions

Category - 1

It is proposed to conduct a study on the behaviour, during and after selected hypothetical severe accident conditions, of instruments used in CANDU reactors. Emphasis would be placed on the accuracy of thermocouples, pressure transducers and flow meters when they operate at the extremes of, or outside, their scales.

Information on instrument behaviour during and after severe accident conditions is scarce. This work, therefore, would generate new knowledge necessary to improve the understanding of instrument readings during abnormal events.

The results of this study would be used in assessing licensee assumptions regarding accident scenarios.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$0.00	$50,000.00

Contract Completed: N.A.

COMMENTS: This project was effectively put on hold to allow SED staff to define the scope and objectives.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.12 Criteria for Identification and Evaluation of Fire Hazards

Category - 1* File Number: 34-2-4-31
Contractor - Professional Loss Control Ltd. (L. Morisson)
Fredericton, N.B.

A contract is under way to develop a comprehensive methodology for assessing fire protection measures in CANDU nuclear power plants.

In the safety analyses of CANDU nuclear power plants it is a requirement that consideration be given to potential fire hazards. The information that would be produced by this contract is necessary to ensure that AECB staff remain in a position to assess authoritatively such hazards.

The results of the contract would be of use to AECB staff in the assessment of licence applications and in the formulation of guidelines appropriate to fire hazards in CANDU nuclear power plants.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$36,000.00	$70,000.00	$0.00	$106,000.00
Actual Spending:	$35,874.00	$69,676.00	$0.00	$105,550.00

Contract Completed: Yes

COMMENTS: Final report accepted.

RESULTS: The final report is in two volumes. Volume 1 provides tutorial background information on fire hazards analysis. Volume 2 sets out procedures and criteria whereby a fire hazards analysis report may be assessed, and recommends what constitutes a good fire hazards analysis report.

EVALUATION: Post Project Evaluation initiated.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.13 Hydrogen Absorption in Zircaloy at High Temperatures

Category - 3

It is proposed to perform experiments to determine whether hydrogen could be absorbed rapidly in Zircaloy at high temperature under hypothetical accident conditions in CANDU reactors. The tasks would include determining the migration rate of hydrogen to colder metal and the resulting degree of pressure tube embrittlement. An earlier phase of this project addressed the rationale of the proposed program, and was completed in FY 84/85.

Information is required by AECB staff on the severity and the size of the problem of hydrogen absorption in Zircaloy at high temperatures.

The outcome of this proposed experimental project would be used in assessing licence submissions on severe accidents which involve pressure tubes at high temperatures.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$18,000.00	$25,000.00	$0.00	$43,000.00

Contract Completed: N.A.

COMMENTS: Cancelled because the research program at WNRE funded by COG-CANDEV addresses the above concerns.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.17 Computer Software Quality Assurance

Category - 1* File Number: 34-0-4-1
Contractor - Prior Data Sciences Ltd. (K.A. Ives)
Ottawa, Ontario

A project is under way which will survey the world literature on latest developments in computer software quality assurance (QA) programmes. The survey would identify what are considered to be the best applicable standards and techniques for QA programmes during the initial development of the software and then subsequently identify applicable standards and techniques for the maintenance and preservation of the software during operation.

The work is proposed because it is essential to have adequate QA procedures for computer software. The AECB therefore needs to be aware of methods for evaluating the adequacy of software QA programmes.

The results of the study will be used in the assessment of licensee software QA programmes and in formulating regulatory requirements for such programmes.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$6,000.00	$14,000.00	$0.00	$20,000.00
Actual Spending:	$6,268.50	$13,631.50	$0.00	$19,900.00

Contract Completed: Yes

COMMENTS:

RESULTS: Criteria were defined for the evaluation of software quality assurance (SQA) elements with respect to nuclear power reactor software from a regulatory viewpoint. A number of SQA standards were analyzed and the relevant elements were extracted and discussed based on these criteria. Ten general recommendations and 24 specific recommendations were made concerning SQA requirements for nuclear power reactors.

EVALUATION: Not yet initiated.

PUBLICATIONS: INFO 0201, "Computer Software Quality Assurance".

REVIEW PANEL ACTIVITIES:

84.1.19 Adequate Meteorological Monitoring

Category - 1* File Number: 34-3-2-8
Contractor - Concord Scientific Corporation (R. Portelli)
Downsview, Ontario

It is proposed to fund a project which would examine the meteorological input requirements for airborne dose dispersion calculations. The project would determine the minimum input data required and thence recommend efficient and reasonable requirements for meteorological monitoring instrumentation.

The AECB plans to issue a document specifying details of what constitutes "adequate" meteorological data in airborne dose dispersion calculations. A review is therefore required of meteorological input data requirements.

The results of the study would be used as input information to the production of the planned regulatory document which will specify what constitutes "adequate" meteorological data for licensing certain nuclear facilities, such as power reactors and heavy water production plants.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$20,000.00	0.00	$0.00	$20,000.00
Actual Spending:	$19,764.83	$0.00	$0.00	$19,764.83

Contract Completed: Yes

COMMENTS:

RESULTS: The final report identified what constitutes "adequate" meteorological information for airborne dispersion calculations relating to "normal operation", "design postulated accidents", and "emergency situations" for nuclear facilities. Specific requirements are identified for model input parameters and methods for obtaining the parameters. Finally, recommended data acquisition methods are presented.

EVALUATION: Post Project Evaluation initiated.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.20 A Tool to Analyze Real-Time Programs

Category - 1

A project is proposed to survey the latest developments in computer program analysis and testing, using graph theory as applied to real-time critical systems. Then, based on the results of the survey, it is proposed to acquire or develop a program graphing software tool to analyze the complexity and verification/validation test coverage aspects of safety-related nuclear system software.

Due to the combination of the number of inputs and processing pathways, computer programs used to control nuclear reactor systems are very difficult to verify and validate to an acceptable degree of confidence. Even using extensive test data some design and programming faults may go undetected resulting in the possibility of a critical failure at some future time given a certain set of input and processing conditions.

The results of the survey phase would provide AECB staff with the latest information concerning analysis of critical software, enabling a knowledgeable assessment of the particular methods and test data used by licensees to verify and validate their nuclear software. The resulting software tool may provide an effective means for AECB staff to rigourously and independently evaluate the testability of a particular system and the extent of test coverage proposed by the licensee.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$0.00	$60,000.00

Contract Completed: N.A.

COMMENTS: Due to limited availability of project management staff time, this project could not be initiated during FY 86/87.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S4 (Planned)

84.1.26 Review of Control Room Emergency Operating Procedures

Category - 1* File Number: 34-12-0-4
Contractor - Human Factors North Inc. (N. Moray)
Toronto, Ontario

It is proposed to continue a project which will review recent approaches to the development of nuclear plant control room emergency operating procedures and assess the need for improved emergency operating procedures in CANDU nuclear power plant control rooms. In addition, the project will develop a set of criteria for regulatory assessment of existing or proposed CANDU control room emergency operating procedures.

This project was prompted by published new approaches to the development of control room emergency operating procedures coupled with the need for the AECB to establish regulatory assessment criteria on the topic.

The results of this human factors project would be used by the AECB to identify potential inadequacies in existing nuclear power plant control room emergency operating procedures and to assess proposed changes to these procedures.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$44,000.00	$56,000.00	$0.00	$100,000.00
Actual Spending:	$47,461.00	$57,305.00	$0.00	$104,766.00

Contract Completed: Yes

COMMENTS:

RESULTS: The project examined the field of emergency operating procedure (EOP) development and practice world-wide. It developed methodologies to supplement existing techniques and practices for the production of EOPs, and prepared criteria for assessing Canadian practice for such production. The final report recommends that symptom-based EOPs be preferred over event-based EOPs. The concept of an Emergency Operating Procedure Philosophy is introduced, defining the method whereby effective EOPs are produced. A recommended EOPP is developed from which a sample EOP is derived. Finally, gaps in the existing state of knowledge concerning EOPs are identified.

EVALUATION: Post Project Evaluation in progress.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.27 Practices for the Upkeep of Overpressure Protection Devices

Category - 1* File Number: 34-2-4-34
Contractor - J.L. Sisk Associates Limited (J.L. Sisk)
Fredericton, N.B.

The title of this project was changed to reflect the intent of broadening the scope to include all types of overpressure protection devices. It is proposed to continue with a critical survey to examine, summarize, comment, and make recommendations as necessary on field practices for maintenance, repair, testing and setting of overpressure protection devices in nuclear and other industrial installations.

The work was proposed to generate information necessary to assess licensee compliance with the appropriate codes and standards.

The findings of the survey will be used to assess compliance with the licensing conditions in this area of PRC regulation.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$25,000.00	0.00	$0.00	$25,000.00
Actual Spending:	$24,952.00	$0.00	$0.00	$24,952.00

Contract Completed: Yes

COMMENTS:

RESULTS: The report presents a summary of present practices for the maintenance and repair of overpressure protection devices. The significant recommendations, directed at the provincial regulatory bodies having jurisdiction over pressure-retaining systems and components, include:
- that a single person be responsible for setting and sealing of the devices at each nuclear facility;
- that a Quality Control Manual be approved and actual practices audited; and
- that the personnel performing the testing and maintenance of the devices be properly certified to the satisfaction of the provincial jurisdiction.

EVALUATION: Contract objective was achieved. Recommendations have been passed on to the Rewrite Committee of CSA Standard B51-M1981 for possible incorporation into Appendix D entitled "Guidelines for Safety/Relief Valve Repair Organizations".

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.28 Flaw-Sizing Using Ultrasonic Techniques

Category - 1* File Number: 34-2-6-2
Contractor - Techno Scientific Inc. (Dr. M. Macecek)
Downsview, Ontario

It is proposed to continue a state-of-the-art review and perform tests to characterize, compare and highlight the variation in indications obtained by ultrasonic techniques when used for flaw sizing.

The data are needed to provide independent information on ultrasonic techniques and their limits of applicability.

The outcome of the review will be used to evaluate the adequacy of the techniques and equipment used by licensees in sizing defects and flaws.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$9,000.00	0.00	$0.00	$9,000.00
Actual Spending:	$9,000.00	$0.00	$0.00	$9,000.00

Contract Completed: Yes

COMMENTS: This contract was initiated to provide the scientific and technical basis for a review of an updated Non-Destructive Examination procedure submitted by a licensee. The draft final report contained portions written by the subcontractor which had some merit. However, these portions were rewritten by the principal investigator in a form which was unsatisfactory. The contract was terminated at 60 percent of the original cost.

RESULTS:

EVALUATION: None of the tasks was addressed satisfactorily by the contractor. Unsuccessful attempts were made by AECB staff to resolve the problems. It will be necessary to try to obtain a new contractor to complete the work.

PUBLICATIONS: The final report delivered by the contractor will not be published in the INFO series and has been retained in the contract file.

REVIEW PANEL ACTIVITIES:

84.1.30 Fuel/Moderator Interaction after Pressure Tube Rupture

Category - 1* File Number: 34-2-5-5
Contractor - Swacer Inc. (Prof. J.H.S. Lee)
Outremont, Quebec

It is proposed to conduct a study to investigate the potential for steam explosion resulting from molten fuel/moderator interaction following a postulated fuel channel blockage accident. The investigation would involve a critical review of the available experimental and analytical information on the subject.

The study would provide AECB staff with independent information with which to assess whether a steam explosion could occur in, and whether existing models are adequate to describe, a fuel channel blockage event in a CANDU reactor.

The results of this study would be used by AECB staff in assessing licence submissions on fuel channel blockage accidents.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$32,000.00	$17,000.00	$0.00	$49,000.00
Actual Spending:	$31,860.00	$17,540.00	$0.00	$49,400.00

Contract Completed: Yes

COMMENTS:

RESULTS: The literature review indicated that an energetic high yield steam explosion cannot be regarded as an improbable event if large quantities of coarse-fragmented molten fuel are mixed with the moderator. To obtain an estimate of the upper-bound pressure loadings, a model based on an underwater explosion of a pressurized volume of steam should be developed.

EVALUATION: Post Project Evaluation initiated.

PUBLICATIONS: INFO 0227, "Molten Fuel-Moderator Interaction: An Investigation of the Potential for Steam Explosion".

REVIEW PANEL ACTIVITIES:

84.1.31 Secondary Side Heat Sink Performance

Category - 3

A project is proposed which would provide a computer simulation of the performance of the secondary side heat sinks of a nuclear reactor.

Current safety analyses do not include all the factors which affect the secondary side response to plant transients - factors such as control algorithms, default values in software, component protection, etc. The proposed project would identify all such constraints and simulate their interaction with the physical performance of the secondary side to obtain a more realistic indication of the secondary site response.

The output of the project would be a computer simulator which would enable AECB staff to evaluate more fully the assumptions in existing safety analyses which address heat sink adequacy.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$0.00	$50,000.00

Contract Completed: N.A.

COMMENTS: Project cancelled and superseded by project 86.1.21.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.32 Vibration Probe Monitoring of Structure Deterioration

Category - 2

It is proposed to conduct a study on the possible use of vibration probes for monitoring the long-term deterioration of CANDU structures such as supports for vessels and piping.

Changes that occur with time in vibration frequency and mode shape may be precursors to structural deterioration. This work would develop a monitoring system and address the accuracy required to achieve estimates of the degree of deterioration. This work will not be proposed for commencement until the results of 84.1.39 have been assessed.

The results of the project would assist AECB staff in deciding whether vibration monitoring is a potentially valuable diagnostic tool that should be installed in nuclear plants.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$0.00	$25,000.00

Contract Completed: N.A.

COMMENTS: This project was cancelled. Projects 84.1.39 and 85.1.11 showed the feasibility of vibration monitoring of major NPP components as a means of determining their mode shapes and natural frequencies. Field experience with this technique is required before assessing its application to monitoring of structure deterioration. Ontario Hydro has been asked to use the technique for the verification of seismic analyses of major equipment at Darlington NGS. The proposed project is cancelled although the subject may be raised in the future depending on the field experience results.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.1.38 Crack and Fracture Behaviour in Tough Ductile Materials

Category - 1* File Number: 34-2-6-6
Contractor - University of Toronto (D.W. Hoeppner)
Toronto, Ontario

It is proposed to complete a critical review of the criteria which govern crack initiation and growth, and fracture instability in tough ductile materials.

The study will compile and critically review the state-of-the-art knowledge on elastic-plastic and fully plastic fracture for the purpose of enhancing the effectiveness of defect assessment and fracture appraisal.

Knowledge gained in this study would be used by the staff of the AECB, and other regulatory agencies, to review current defect appraisal procedures and techniques.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$25,000.00	0.00	$0.00	$25,000.00
Actual Spending:	$24,981.00	$0.00	$0.00	$24,981.00

Contract Completed: Yes

COMMENTS:

RESULTS: The report describes the various approaches and developments as they pertain to the understanding of crack and fracture behaviour in tough ductile materials. The fundamental elastic fracture mechanics concepts based on the concepts of energy, stress field, and displacement are introduced and their interrelationships demonstrated. The extension of these concepts to include elastic-plastic fracture mechanics considerations are reviewed in the context of the preferred options available for the development of appropriate design methodologies.

EVALUATION: Contract objective was achieved. Quality of work was excellent. Results of the project have been used by AECB staff in the review of licensee submissions, and a follow-up project (85.1.8) was initiated to further the development of a practical method for the analysis and assessment of stable crack growth under elastic-plastic strain conditions.

PUBLICATIONS: INFO 0169, "Crack and Fracture Behaviour in Tough Ductile Materials".

REVIEW PANEL ACTIVITIES:

84.1.39 Mode Shape and Frequency Identification for Seismic Analysis

Category - 1* File Number: 34-2-4-33
Contractor - Acres Consulting Services (Z. Wozniak)
Niagara Falls, Ontario

It is proposed to continue with a study to explore the feasibility of using broad band background vibrations to determine mode shapes and frequencies of structures and components in a nuclear power plant.

The information is needed to help decide whether vibration probes can be used to verify analytically derived frequencies and mode shapes of key seismically qualified components.

The results of this contract would inform AECB staff of the type and location requirements of transducers, the type of equipment and the techniques required for data acquisition and reduction, the accuracy that can be achieved and the approximate cost of installing such a vibration identification system.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$24,000.00	0.00	$0.00	$24,000.00
Actual Spending:	$24,040.00	$0.00	$0.00	$24,040.00

Contract Completed: Yes

COMMENTS:

RESULTS: Spectral techniques have been developed for determining the frequency response function of major CANDU equipment from measured vibration response to background excitation. The resulting natural frequencies and mode shapes are then evaluated graphically from the frequency response function plots. Commercially available equipment necessary for the measurement of background vibration in a CANDU plant has been identified. Recommended work includes an experimental program to verify the methodology developed in this study, and a theoretical study to improve the accuracy of the mode shape and natural frequency prediction.

EVALUATION: Contract objective was achieved. Both quality and quantity of work were very good. A follow-up project (85.1.11) was initiated to improve the speed and accuracy of the method developed under this contract, and to verify it experimentally.

PUBLICATIONS: INFO 0190-1, "Mode Shape and Natural Frequency Identification for Seismic Analysis from Background Vibration".

REVIEW PANEL ACTIVITIES:

85.1.3 Reliability of Microcircuits in Nuclear Power Plants

Category - 1* File Number: 34-2-6-7
Contractor - Spar Aerospace Limited (Dr. P.M. Cross, R.C. Taplin)
Ottawa, Ontario

It is proposed to conduct a study to collect and critically review available information on the limitations of microcircuits used in a nuclear environment.

Microcircuits are being used more extensively for control and monitoring functions in nuclear power plant designs. Since these circuits operate on very small currents, it is necessary to have state-of-the-art information on their susceptibility to transients and other external influences which may affect their operation.

The results of the proposed work would be used to evaluate the adequacy of present licensee design guidelines with regard to the use, qualification and separation of microcircuits in certain areas of nuclear power plants.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$10,000.00	$15,000.00	$0.00	$25,000.00
Actual Spending:	$13,308.00	$13,308.00	$0.00	$26,616.00

Contract Completed: Yes

COMMENTS:

RESULTS: The reliability problems associated with using microcircuits in nuclear power plant control systems were studied. Twelve general problem areas were identified and 23 specific recommendations were made. The study has shown that microcircuits intrinsically increase reliability but that the manufacturing, installation, operations and maintenance phases must be carefully controlled to avoid degrading this intrinsic reliability.

EVALUATION: Not yet initiated.

PUBLICATIONS: INFO 0220, "Reliability of Microcircuits in Nuclear Power Plants".

REVIEW PANEL ACTIVITIES:

85.1.4 **Aerosols and Fission Product Transport

Category - 1 File Number: 34-2-6-13
Contractor - Autolycus Research (Dr. W.J. Megaw)
Thornhill, Ontario

A project is proposed to investigate the potential effects of aerosols on fission product transport within and without reactor containment, and to assess mathematical models and computer codes used to describe aerosol behaviour.

Recent advances in the modelling of fission product behaviour in containment are resulting in decreases in the predicted quantities of gas-phase radioisotopes available to contribute to public radiation doses after a postulated accident in a CANDU nuclear power plant. This implies that the relative importance of the airborne liquid-phase and airborne solid-phase components has been increased. The intent of this project would be to perform an initial evaluation of the extent of this potential contribution to doses, and to assess the suitability of available mathematical models for CANDU safety analyses.

The results of this project would be of use to AECB staff both in the formulation of guidelines and requirements for safety analyses and in the assessment of future license applications for CANDU nuclear power plants in which aerosol modelling may be included.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$35,000.00	$60,000.00

Contract Completed: No

COMMENTS: The two proposals originally received were rejected as technically unsatisfactory. Autolycus Research was then invited to submit a proposal.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.1.6 Vibration Forcing Function on Primary Pumps: Data Analysis

Category - 1* File Number: 34-2-5-6
Contractor - Carleton University (Prof. T.C. Currie)
Ottawa, Ontario

It is proposed to analyze the experimental data collected during Pickering and Bruce primary pump tests performed in Ontario Hydro's Kipling laboratory. The aim is to provide an interpretation as to why the pump head degradation showed a strong dependance on loop temperature. A mathematical model would be used to aid in interpreting the data.

Under several postulated events, the primary pumps may experience head pulsation that may lead to damaging some of the pump internals. The information that would be produced by this project is necessary to correlate pump head pulsation to operating conditions and loop geometry.

The results of this contract will be used primarily as a corner stone towards calculating pump head pulsation frequency and formulating the forcing function on pump internals.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$11,000.00	0.00	$0.00	$11,000.00
Actual Spending:	$10,834.51	$426.63	$0.00	$11,261.14

Contract Completed: Yes

COMMENTS:

RESULTS: This project produced a review of phenomena which have been known to cause pump-induced flow oscillations in pressurized piping systems under two-phase conditions. The data of Pickering and Bruce pump tests were then analyzed to determine which of the reviewed phenomena could be responsible for the head pulsation and pipe vibrations observed in these tests. It was concluded that suction pump geometry plays an important role in promoting instabilities in the piping system. Additional experiments to verify this conclusion were recommended.

EVALUATION:

PUBLICATIONS: INFO 0209, "Analysis of Data Obtained in Two-Phase Flow Tests of Primary Heat Transport Pumps".

REVIEW PANEL ACTIVITIES:

85.1.7 **The Use of Full-Scope Simulators in Training and Qualification

Category - 1 File Number: 34-2-4-37
Contractor - Human Factors North (J. Senders)
Toronto, Ontario

A project is proposed which would encompass a review of and recommendations for methods by which CANDU nuclear power plant control room operators and shift supervisors could be tested by the utilities during training, and by the AECB for certification purposes using full-scope simulators. This project would also develop an experimental method for evaluating full-scope simulator testing methods.

This project is required to support the activities of the AECB Operator Certification Group and to ensure that control room operators and shift supervisors are suitably tested by the utilities during simulator training and are effectively examined by the AECB on full scope simulators for certification purposes.

The result of this project will be used by the AECB Operator Certification Group to assess the adequacy of the utilities' simulator testing methods for shift supervisors and control room operators and in the continuing development of effective certification examinations.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$0.00	$50,000.00
Actual Spending:	$0.00	$32,500.00	$58,305.00 (Estimate)	$90,805.00 (Estimate)

Contract Completed: No

COMMENTS:

RESULTS: The literature has been reviewed. Arrangements are being made to field test a proposed testing method at the Pickering B simulator.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.1.8 **Crack Propagation in Tough Ductile Materials

Category - 1 File Number: 34-2-6-8
Contractor - University of Toronto (R.D. Venter)
Toronto, Ontario

It is proposed: a) To perform experimental work which would examine elastic-plastic fracture behaviour in steels which are typical of materials used in CANDU primary heat transport systems; and to explore whether small specimen tests can be used to characterize "lower bound" crack behaviour under the range of elastic-plastic strain conditions encountered in CANDU primary heat transport system components (Phase 1). b) To evaluate the effectiveness of crack displacement and energy based fracture toughness methods of describing crack propagation behaviour under elastic-plastic strain conditions. This should include studies of the individual approaches and an investigation into the viability of a combined energy and crack displacement approach as a route towards a representative model for a wide range of crack growth (Phase 2).

The project arises from the recommendations of a recently completed review of crack and fracture behaviour in tough, ductile materials (84.1.38), which showed a need to incorporate elastic-plastic fracture mechanics considerations into the analysis and design of metallic structural components. The project is aimed at the eventual development of a practical method for the analysis and assessment of stable crack growth under elastic-plastic strain conditions.

The results of the project would be used as reference information to enable more effective appraisal of safety margins in defect dispositioning and other crack stability assessment work.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$75,000.00	$15,000.00	$90,000.00
Actual Spending:	$0.00	$45,000.00	$45,000.00 (Estimate)	$90,000.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. Experimental work described above under a) completed. Phase 1 report due July 1987.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.1.9 **Ultrasonic Defect-Sizing Using Decibel Drop-Off Methods

Category - 1 File Number: 34-2-6-9
Contractor - New Brunswick Research and Productivity Council
(Dr. R. Murphy)
Fredericton, N.B.

It is proposed to conduct a literature review to investigate the effectiveness of the decibel drop-off technique in sizing defects. Studies would be conducted using beam axial and beam profile methods at various dropping levels. This would be a follow-up to a previous study (84.1.28) in which a general review of ultrasonic techniques was carried out.

Due to the diversity of defect-sizing methods which are based on the decibel drop-off technique, the accuracy and repeatability of the technique have become a matter of importance. Information is, therefore, needed to provide an independent assessment of the limits of applicability of the decibel drop-off methods.

The results of this project would be used in evaluating licence submissions involving the use of decibel drop-off methods in the sizing of defects in welds, piping, pipe fittings and pressure vessels.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$9,000.00	$25,000.00	$0.00	$34,000.00
Actual Spending:	$0.00	$34,497.00	$0.00 (Estimate)	$34,497.00 (Estimate)

Contract Completed: No

COMMENTS: Draft final report submitted.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.1.10 **Simulation of Darlington NGS Shutdown and Regulating Systems

Category - 1 File Number: 34-2-4-28
Contractor - Serdula Systems Ltd. (K. Serdula)
Deep River, Ontario

It is proposed to fund a project to modify the computer-based interactive simulation program SLISIM to model the features of the shutdown and regulating systems of Darlington NGS. In addition, the opportunity would be taken to improve the presentation of the output of the program.

Analysis of possible interactions between reactor shutdown and regulating systems involves the simultaneous consideration of many variables. The most effective tool for assisting an analyst is a simulation program. Such a program, called SLISIM, has already been developed for the AECB. The program was specifically tailored to model the features of a 600 MW CANDU reactor. The AECB wishes to repeat the study of potential interactions of shutdown and regulating systems for the proposed Darlington NGS, and therefore SLISIM has to be modified.

The results of the project would be an interactive simulation program which would be used in the AECB safety review of the proposed Darlington NGS.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$1,000.00	$29,000.00	$0.00	$30,000.00
Actual Spending:	$0.00	$26,629.95	$0.00	$26,629.95

Contract Completed: Yes

COMMENTS:

RESULTS: The project produced a microcomputer-based interactive simulation program which models the features of the shutdown and regulatory systems of Darlington NGS. The program is being used in the continuing safety analysis of the reactor.

EVALUATION: Post Project Evaluation in progress.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.1.11 Mode Shape and Frequency Identification for Seismic Analysis II

Category - 1 File Number: 34-2-4-33
Contractor - Acres Consulting Services Ltd. (Z. Wozniak)
Niagara Falls, Ontario

It is proposed to continue with a study to explore the feasibility of using broad band background vibrations to determine mode shapes and frequencies of structures and components in a nuclear power plant. The work proposed includes improvement of the speed and accuracy of the method developed during Phase I (84.1.39) of the Study, and its experimental verification.

The information is needed to help decide whether vibration probes can be used to verify analytically derived frequencies and mode shapes of key seismically qualified components.

The results of this contract would inform AECB staff of the type and location requirements of transducers, the type of equipment and the techniques required for data acquisition and reduction, the accuracy that can be achieved and the approximate cost of installing such a vibration identification system.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$78,000.00	$3,000.00	$0.00	$81,000.00
Actual Spending:	$54,000.28	$10,990.72	$0.00	$64,991.00

Contract Completed: Yes

COMMENTS:

RESULTS: Background vibration in a CANDU plant, which results from ambient environmental noise such as operation of pumps, fans and fluid flow in pipes, can be used to determine the dynamic characteristics of major plant equipment, e.g., the calandria, the fuelling machines and the primary heat transport pumps. An analytical method, which uses a Fast Fourier Transform and a curve fitting technique, was developed to obtain the dynamic characteristics in the form of mode shapes, natural frequencies and damping ratios from accelerations measured at several points on a structure; knowledge of the excitation forces is not required. Results of laboratory experiments confirm that this method can be used to verify seismic analysis of major equipment in a CANDU plant.

EVALUATION: Contract objective was achieved. Both quality and quantity of work were high. The AECB intends to ask Ontario Hydro to verify its analytical calculations by in-situ measurements at Darlington NGS.

PUBLICATIONS:

1) INFO 0190-2, "Mode Shape and Natural Frequency Identification for Seismic Analysis from Background Vibration - Phase II".

2) "Mode Shape and Natural Frequency Identification for Seismic Analysis from Background Vibration", by S. Bhan, Z. Wozniak and K. Asmis, Proc. of Fifth Canadian Conference on Earthquake Engineering, Ottawa, July 1987 (to be published).

REVIEW PANEL ACTIVITIES:

86.1.1 **Selection of Equipment for Equipment Qualification

Category - 1 File Number: 34-2-4-40
Contractor - Monserco Ltd. (K.G. Torr)
Mississauga, Ontario

It is proposed to identify equipment and components of CANDU NPPs whose impairment could result in significant impact on plant safety and which, therefore, should be qualified for exposure to accident and post-accident environmental conditions. This identification would be based on a review of existing reliability analyses, safety design matrices and expert knowledge of the design and operation of the plant systems.

Comprehensive environmental qualification of NPP equipment will be carried out for the first time in Canada for the Darlington NPP. As a result, AECB staff will have to assess the adequacy of equipment qualification as a part of the Darlington NPP licensing process. In addition, AECB staff wish to review the environmental qualification of safety-related equipment in already operating plants.

This project would identify the significant safety-related equipment and components that should be qualified for the Darlington NPP, and which should be considered for qualification at operating NPPs. Using the results of the work, AECB staff would be able to confirm whether the identified equipment and components were included in the equipment qualification process.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$0.00	$50,000.00
Actual Spending:	$0.00	$10,000.00	$39,860.00 (Estimate)	$49,860.00 (Estimate)

Contract Completed: No

COMMENTS: Final report due 1986-09-30. Component data sheet format was set up and equipment identification for CANDU 600 containment system started.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.2 **Technical Basis for Equipment Qualification Assessments

Category - 1 File Number: 34-2-4-38
Contractor - Monserco Limited (K.G. Torr)
Mississauga, Ontario

It is proposed to fund a project which has the following objectives:
a) to compile existing Canadian and foreign regulatory requirements and industry standards pertinent to NPP equipment qualification (EQ) and to determine the currency of these requirements in the light of up-to-date research results;
b) to prepare an EQ review procedure for use by the AECB in assessing EQ licensing submissions; and
c) to recommend evaluation criteria for use in the assessment of CANDU EQ licensing submissions.

Canadian regulatory requirements for the EQ of NPP equipment are expressed in general terms in proposed regulatory guides for the special safety systems. However, no criteria or guidelines that would establish which qualification methods are acceptable are given. Thus, it is important to develop a technical basis for review of EQ licensing submissions.

The project will produce a documented technical basis, a review procedure, and evaluation criteria for use by AECB staff in the assessment of Darlington EQ licensing submissions, and in the assessment of the adequacy of the environmental qualification of selected safety equipment and components in operating NPPs.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$0.00	$40,000.00
Actual Spending:	$0.00	$27,980.00	$11,420.00 (Estimate)	$39,400.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. Final report due May 1987.

RESULTS: Review of regulatory requirements and industry standards was completed.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.3 Survey of NPP Environments for Equipment Qualification

Category - 3

It is proposed: a) to determine the expected type and range of actual plant environments (in selected plants and plant areas) to which various safety-related equipment and components are normally exposed during their service life; and b) to assess if the currently used accelerated aging methods account for these environments. The contractor would obtain available data on measured plant environments (e.g. radiation, thermal, mechanical stress, gas), and, as necessary, would measure actual environments during plant operation in selected plants and plant areas, and would assess the type and range of the environments and their simulation by the currently used accelerated aging methods.

To assure a conservative basis for equipment qualification testing, equipment should be tested in a state equivalent to the end-of-qualified life condition. Since it is not practical to naturally age equipment to the end-of-life condition, accelerated aging techniques are used to change the equipment to be tested to a state equivalent to end-of-life. To be able to simulate natural aging, actual plant environments must be known.

The project results would enable AECB staff to assess whether the accelerated aging methods reported in EQ licensing submissions adequately account for normal NPP environments.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.4 Assessment of NPP Aging and NPP Maintenance Programs

Category - 1

It is proposed to fund a project which has the following objectives: a) to compile and evaluate information on aging effects that have occurred to date in selected types of electrical and mechanical components and materials in complex industrial plants and which could result in degradation of the performance of such components over the expected plant life; b) to identify failure modes related to the aging and service wear of the components; c) to identify precursor indicators of the potential failure modes that could be monitored at reasonable cost and plant operator radiation dose to detect approach to failure at an early stage; d) to identify any standards relating to aging that are applicable to CANDU NPPs; and e) to recommend criteria for the evaluation of NPP equipment monitoring and maintenance programs to determine whether these programs adequately account for aging and service wear effects that could have a significant effect on plant safety. The project work would involve a survey, review and evaluation of complex industrial plant (including NPP) operating experience, equipment monitoring and maintenance practices, and a review of the relevant literature.

As the components in nuclear power plants get older, the aging and service wear they experience may have an impact on their ability to perform their intended functions. Only a few industrial standards provide guidance on equipment monitoring and maintenance. These standards are very general in nature and deal only with a limited number of component types. Thus, the availability of a well-founded methodology for the assessment of aging of critical components, equipment and systems, and their impact on plant safety would be of value. The proposed project would be the starting point in the development of this methodology.

The information generated by this project would be used by AECB staff as an initial technical basis for assessing the impact of aging of NPP equipment on plant safety and for the possible development of regulatory requirements. Furthermore, the results would allow AECB staff to review and assess the adequacy of NPP monitoring, maintenance and replacement programs related to the detection and mitigation of aging and service wear effects in NPP equipment.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$60,000.00	$90,000.00

Contract Completed: N.A.

COMMENTS: Cancelled and replaced by component-specific projects such as 86.1.20.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.8 Pump Behaviour and Piping Stress under Off-Design Loadings - Feasibility Study

Category - 1

It is proposed to examine the feasibility of conducting an experimental program to investigate the behaviour under two-phase conditions of a scaled-down pump, equivalent to a CANDU heat transport pump, with a variable speed motor. Using the same pump with some modifications in the piping system, it is further proposed to examine the feasibility of performing a series of experiments to identify the stresses and failure modes of a simulated primary heat transport piping system when subjected to irregular hydraulic loadings generated by off-design operating conditions of the main coolant pumps. Typically, off-design operation would include that expected during loss-of-coolant accidents.

In full-scale tests conducted by a licensee, pump suction voidage could not be measured. This parameter is important in characterizing pump performance under two-phase conditions, and should be possible to measure with smaller diameter pipes. In addition, pump operation under off-design conditions could lead to violent vibration and possible failure of piping. Representative experiments in which test conditions could lead to damaging full-size pumps and piping are not normally performed because of the high cost. Therefore, the necessary data can only reasonably be obtained by the proposed use of scaled pumps.

The findings of this feasibility study would indicate whether, and at what cost, the proposed experiments could be performed. If such experiments were to be carried out, the information obtained would assist AECB staff in assessing licencing assumptions concerning pump and piping behaviour during loss-of-coolant, or similar accidents.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$27,000.00	$25,000.00	$100,000.00	$152,000.00

Contract Completed: N.A.

COMMENTS: Cancelled. Ontario Hydro is conducting a multi-year experimental program involving two model pumps of two scales. The objective of the Ontario Hydro pump program is to investigate the hydraulic behaviour of the model pumps and the piping attached thereto under numerous single-phase and two-phase conditions. AECB Project 86.1.8 was therefore cancelled, and an information exchange process between staff of the AECB and Ontario Hydro was set up.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.10 Fuel Element Susceptibility to Bowing in Dryout Conditions

Category - 3

It is proposed to conduct an experimental investigation of the susceptibility of fuel elements to bowing if operated in conditions of partial dryout. The study would focus on the behaviour of a 'trefoil' under representative reactor conditions.

A new criterion has been proposed by licensees for regional overpower trip system design which would permit operation of fuel elements in dryout at a power level approximately 5% above that at the onset of intermittent dryout. Current industry plans for supporting research involve an investigation of the consequences of a specific bowing shape. This proposed project would first demonstrate whether bowing could occur and, if so, under what conditions and with what resulting shape. Such information is essential in assessing the dryout and post-dryout behaviour to fuel bundles.

The results of this project would assist AECB staff in deciding on the acceptability of the criterion proposed by licensees. The information obtained would also add to the state-of-knowledge in this field.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$65,000.00	$0.00	$65,000.00

Contract Completed: N.A.

COMMENTS: Cancelled. Proponent (SED) has advised RRB that AECL-CRNL is performing related experiments and computer code analysis, and that the request for this project was being withdrawn.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.11 Molten Fuel/Water Interaction - Load Quantification

Category - 3

It is proposed to experimentally determine the loads generated in a closed tank of water by the rapid addition of material simulating molten fuel. Determination of energy conversion factors and the form of the energy conversion would be carried out. This proposed contract would follow, and would depend on the results of, a current contract examining fuel moderator interaction (84.1.30).

An uncooled fuel channel could rupture and deposit molten fuel, steam and gas into the moderator. This would result in a rapid transfer of energy to the moderator and could generate violent shock and pressure waves.

The results of the project would be used in assessing licensee claims concerning the integrity of the reactor core under accident conditions.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$100,000.00	$50,000.00	$150,000.00

Contract Completed: N.A.

COMMENTS: Cancelled. Results of Project 84.1.30 indicated that the degree of severity (as measured by the energy conversion factor) of steam explosion may depend on parameters such as mode of mixing, fragment size and spacing and geometry. After discussions with the proponent (CQAD), it was decided that this project be dropped.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.12 Hydrogen Burn Characteristics of Vented Enclosures

Category - 3

It is proposed to fund experimental work on a vented enclosure which has similar volume, volume-to-surface area ratio, volume-to-vent area ratio and obstacle configuration as a CANDU calandria. The project would determine hydrogen, oxygen and helium mixture ratios which in the event of ignition of the mixture would (a) prevent effective venting and (b) allow detonation of the mixture.

The safety analyses of hydrogen burning in calandria are based on empirical relationships. They assume that effective venting occurs and that no detonation occurs. Recent results from research have cast doubts on the validity of these assumptions. Therefore, work is required which examines the limits of validity of the two assumptions.

The results of the project would be used in the assessment of the continued acceptance of safety analysis assumptions of adequate venting and no detonation in hydrogen burns in a calandria.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$0.00	$60,000.00

Contract Completed: N.A.

COMMENTS: Project cancelled and replaced by 87.1.8 and 87.1.9.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.13 **Ice Plugging of Pipes Using Liquid Nitrogen

Category - 2 File Number: 34-2-6-12
Contractor - Glencor Engineering Ltd. (Mr. R. Twigg)
Nepean, Ontario

It is proposed to conduct a critical review of information on the use of liquid nitrogen freezing of large-diameter ferritic piping, and to assess the risks associated with its proposed routine use on CANDU piping. The review would examine both jacket freezing and liquid nitrogen injection freezing.

Licensees use ice plugging technique regularly on small-diameter piping and propose to use it on large diameter piping. The work being proposed is intended to address AECB staff concerns regarding the short- and long-term effects of freezing on piping integrity.

The outcome of this project would be used to identify and assess the conditions under which ice plugging may be used on reactor piping.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$0.00	$25,000.00
Actual Spending:	$0.00	$23,980.00	$0.00 (Estimate)	$23,980.00 (Estimate)

Contract Completed: No

COMMENTS: Near completion, draft report received.

RESULTS: This study concluded that ice plugging appears to be a viable method of sealing pipes in non-hazardous service provided that: (1) proper planning and adherence to specific procedures are practised; (2) the use of the method is limited to piping up to 300 mm in diameter; (3) repeated freezing is avoided in the same location on ferritic materials; and (4) each freezing is treated as a "significant event" with a significant event report to be issued after each freeze.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.14 **Survey of Software Configuration Control Methods

Category - 2 File Number: 34-2-6-14
Contractor - Prior Data Sciences Ltd. (G. Pelletier)
Kanata, Ontario

A project is proposed which would survey presently available software configuration control methods and assess which of these techniques are applicable, and to what extent, to configuration control of software in nuclear power plants during the development, commissioning and operational phases. This proposal would proceed only after an evaluation of a current project on computer software quality assurance (84.1.17).

The use of software in nuclear power stations is increasing, mainly due to the introduction of computer control for safety systems. This increases the requirements for systematic configuration control due to the use of similar software in different power plants. Because use of improperly configured software (e.g. use of a wrong version for a certain routine) could adversely impact on safety, the AECB needs to be aware of the relative merits of individual methods, including the most recent developments.

The results of the study would be used as an input in assessing licensees' submissions on configuration control of safety and safety-related software.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$20,000.00	$0.00	$20,000.00
Actual Spending:	$0.00	$10,000.00	$10,000.00 (Estimate)	$20,000.00 (Estimate)

Contract Completed: No

COMMENTS: This project was initiated 18 February 1987 following satisfactory completion of project 84.1.17 and is scheduled to finish in May 1987.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S4

86.1.15 **Plant Air Quality following Accidental Radioactive Releases

Category - 1 File Number: 34-2-4-36
Contractor - Envirodyne Limited (P.R. Slawson)
Waterloo, Ontario

It is proposed to perform a literature survey and some experiments to determine the feasibility of calculating reliable estimates of nuclear power plant air quality for accidental airborne releases of radioactive material. The contractor would also be asked to recommend appropriate methods for use in deriving such estimates. Specific topics relevant to air quality would include: building wake effects, ventilation and filtering.

In the assessment of air quality following postulated airborne releases of radioactive material, further information is required on effects which could decrease the quality of air under such conditions by, for example, inverting flows in ventilation systems, or by causing localized high concentrations in such areas as the ECC sump.

The results of this project would be used in determining whether reliable estimates can be made of nuclear power plant air quality for accident conditions, specifically in the evaluation of control room habitability and the appropriateness of assembly areas and evacuation routes. If it is decided that such estimates can be made, further work would be proposed.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00
Actual Spending:	$0.00	$23,679.50	$6,320.50 (Estimate)	$30,000.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress.

RESULTS: The flow visualization experiments are complete. Data analysis is in progress.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.16 Dose Calculations under Transient Conditions

Category - 3

It is proposed to fund a contract to calculate, for a specific reactor site, the individual and population doses for the spectrum of release scenarios defined in the reactor Safety Report. The principal variables of interest are: source release characteristics, weather conditions, and population distribution. It is also proposed to perform sensitivity studies on the model used.

Historically, dose calculations for accidental airborne releases at reactor sites use simple and overly-conservative assumptions such as steady-state release, most severe weather conditions, and fixed receptor location. Information is required with which to calculate more realistic estimates of dose.

The results of the project would be used in the assessment of licensee submissions on accident conditions involving airborne releases, and in gaining experience with previously-recommended "default" weather scenarios. The results of the sensitivity studies will be used to estimate bounding values of model parameters which are expected to be treated probabilistically in licensee submissions on Darlington NGS.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$35,000.00	$0.00	$35,000.00

Contract Completed: N.A.

COMMENTS: Project cancelled. Priority revised to 'low' by SED.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.18 International Piping Integrity Research Group

Category - 1

It is proposed to join an International Piping Integrity Research Group. This group, organized by the U.S. Nuclear Regulatory Commission (USNRC), will examine the fracture behaviour of large piping systems. The proposed program by the USNRC will include: fracture tests done on approximately 60 large-diameter pipes, of which about one third are directly relevant to CANDU; material tests to establish a data base for fracture analysis; assessment of the efficacy of fracture calculations; review of degraded piping; and review of the state-of-the-art analytical and experimental developments.

There is a need to develop and verify the technology to justify: using analytical assessments to disposition piping defects and prescribe inspection frequencies for them; permitting leak-before-break concepts in lieu of mechanical protection for hypothetical pipe ruptures; and current procedures for response to primary heat transport system leaks.

The results would be used to support, or change, the licensing criteria for protection against pipe rupture, to define in-service inspection frequencies, to develop rules for reactor shutdown after leaks have been detected.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$280,000.00	$560,000.00	$840,000.00

Contract Completed: N.A.

COMMENTS: Negotiation is continuing with USNRC to finalize the agreement.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.19 **Microcomputer Software for Heat Transfer Prediction

Category - 1 File Number: 34-2-5-7
Contractor - University of Ottawa (Prof. S.C. Cheng)
Ottawa, Ontario

It is proposed to produce a microcomputer-based method suitable for predicting heat transfer conditions encountered during postulated accident scenarios in CANDU reactors. The proposed software package would incorporate up-to-date information in a simple and user-friendly format.

Various correlations describing the heat transfer processes are found in current licensing codes. There are uncertainties relating to the choice of correlations since they depend on several parameters such as geometry and flow regime. To assist in the analysis of such systems there is a need for a simple and inexpensive tool by which the effect of new correlations on the heat transfer predictions can be examined without running the more complex computer codes.

The resulting software package would be used in the assessment of safety submissions for postulated accident scenarios such as loss of regulation and loss-of-flow events. In particular it would be used to check the heat transfer prediction of the more complex computer codes used in licensing calculations.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00
Actual Spending:	$0.00	$26,671.77	$5,242.23 (Estimate)	$31,914.00 (Estimate)

Contract Completed: No

COMMENTS: Work progressing on schedule.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.20 **Aging of Elastomers in CANDU Pressure Boundary Service

Category - NEW File Number: 34-2-6-10
Contractor - London Nuclear Ltd. (C.A. Van Berlo)
Niagara Falls, Ontario

It is proposed to fund a project which has the following objectives: a) to compile and evaluate information on aging effects in various elastomeric components in CANDU pressure boundary service and which could result in degradation of the performance of such components over the expected plant life; b) to identify failure modes related to the aging and service wear of the components; c) to identify precursor indicators of the potential failure modes that could be monitored at reasonable cost and plant operator radiation dose to detect approach to failure at an early stage; d) to identify any standards relating to aging that are applicable to CANDU NPPs; and e) to recommend criteria for the evaluation of monitoring and maintenance programs to determine whether these programs adequately account for aging and service wear effects that could have a significant effect on plant safety. The project work would involve a survey, review and evaluation of complex industrial plant (including NPP) operating experience, equipment monitoring and maintenance practices, and a review of the relevant literature.

As the components in nuclear power plants get older, the aging and service wear they experience may have an impact on their ability to perform their intended functions. Only a few industrial standards provide guidance on equipment monitoring and maintenance. These standards are very general in nature and deal only with a limited number of component types. Thus, the availability of a well-founded methodology for the assessment of aging of critical components, equipment and systems, and their impact on plant safety would be of value. The proposed project would address time-dependent degradation of various elastomers in CANDU pressure boundary service, and would be the starting point in the development of this methodology.

The information generated by this project would be used by AECB staff as an initial technical basis for assessing the impact of aging of the elastomeric components on plant safety and for the possible development of regulatory requirements. Furthermore, the results would allow AECB staff to review and assess the adequacy of NPP monitoring, maintenance and replacement programs related to the detection and mitigation of aging and service wear effects of the specified elastomeric pressure boundary components.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$35,000.00	$15,000.00	$50,000.00
Actual Spending:	$0.00	$35,120.00	$15,110.00 (Estimate)	$50,230.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. Completed work includes a summary of properties and aging of elastomers and reviews of design requirements and specifications, regulatory requirements and industry standards, recommended procedures and actual practices for operation, monitoring and maintenance. Awaiting draft final report. Final report due May 1987.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.21 A Simulator for Evaluating Emergency Operating Procedures

Category - NEW

A research project is proposed which would produce a series of computer modules which simulate the general features of a CANDU 600 MW reactor. The modules would "plug in" to an existing simulation environment (SIMAK).

This project is prompted by a review of Emergency Operating Procedures (EOP) that indicated the need for an analytical tool to assist in understanding the interaction of various plant systems. For example, during a small LOCA from the steam space above the pressurizer at low power, one would expect the pressure to drop quickly and the pressurizer level to drop by about 10% and then rise rapidly. At full power, the pressurizer level should rise as the pressure drops. Such an hypothesis could be tested with this simulation.

The simulation will be used to develop an understanding of the way in which a CANDU 600 MW reactor responds to various accident conditions. This understanding is required to evaluate the suitability of the form and diagnostics in an EOP.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$15,000.00	$0.00	$15,000.00

Contract Completed: N.A.

COMMENTS: Postponed. Awaiting the procurement of the computer program via Project 86.1.24.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.22 **Adaptation of Thermalhydraulic Codes for Microcomputers

Category - NEW File Number: 34-2-5-8
Contractor - W.L. Wardrop & Associates Ltd. (Mr. D.M. Kawa)
Winnipeg, Manitoba

It is proposed to adapt the WNRE thermalhydraulic, two-fluid code CATHENA for the supermicrocomputer APOLLO 3000 workstation. This computer is one of the most promising supermicrocomputers that the AECB staff is proposing to acquire. The use of such a computer would result in considerable savings in running codes such as CATHENA and FIREBIRD. This cost reduction would give AECB staff extra freedom, for the same level of expenditure, in performing parametric studies of CANDU behaviour under several scenarios. The project would include verification of the APOLLO version of CATHENA against the original version.

AECB staff is planning to use the CATHENA code as part of a study on the performance of the CANDU Emergency Core Cooling System. This code is presently available for use on the main-frame computers at CRNL, and on the VAX machines, but because such equipment is several years older than the APOLLO, the cost of running codes on them is relatively high.

The verified APOLLO version of CATHENA code will be used to study Emergency Core Cooling System performance of CANDU reactors and compare the results with those of FIREBIRD (an APOLLO version of FIREBIRD is presently available for AECB staff use).

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$16,000.00	$0.00	$16,000.00
Actual Spending:	$0.00	$16,441.00	$0.00	$16,441.00

Contract Completed: Yes

COMMENTS:

RESULTS: This contract converted the computer code CATHENA from a VAX computer to operate on an APOLLO work station. The converted version has been verified against the VAX version and agreement was obtained to the sixth decimal place. The know-how of operating the converted version along with a report were satisfactorily delivered to AECB staff.

EVALUATION: Post Project Evaluation not yet initiated.

PUBLICATIONS: INFO 0224, "Conversion of Cathena from the VAX to APOLLO Computer".

REVIEW PANEL ACTIVITIES:

86.1.23 A Review of Expert Systems

Category - NEW

A project is proposed which would review the state-of-the-art in expert systems. An expert system is a computer program which contains a set of specialist knowledge in a particular topic, together with a set of "rules" on how to manipulate the knowledge to provide answers to input questions. The system mimics an expert in the topic, and can process queries in the absence of complete information, as does an expert. The review would encompass: the properties and limitations of expert systems; how proposed expert systems (in such applications as aids to control room operators) should be evaluated; and how such systems could profitably be used in the work of the AECB. The project would also supply a small stand-alone application as a demonstration of the use of expert systems. The application should be suitable for use in the process of investigating the optimum method of evaluating expert systems. A potential candidate for a stand-alone application is in the area of criticality safety.

AECB licensees are currently developing expert systems for potential use in nuclear power plant control rooms. SED staff are already familiarizing themselves with expert systems, in anticipation of licensee submissions on the topic. The contract would aid in this familiarization by providing background information and a specific operating system for use by AECB staff in investigating the properties of expert systems.

The results of the project would aid AECB staff in developing appropriate procedures for evaluating licensee submissions which involve expert systems. An aid in assessing criticality safety submissions would also be produced by the project.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$0.00	$40,000.00

Contract Completed: N.A.

COMMENTS: Project cancelled as it was considered by DRR to be too ambitious for a first contract in this area. Replaced by 86.1.25.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.24 Acquisition of a Simulation Shell Program and Documentation

Category - NEW File Number: 34-2-4-41

It is proposed to purchase from AECL a computer program called SIMAK and have prepared complete documentation. The program allows interactive simulation to be run on an IBM PC when modules of specific models are "plugged in" to the SIMAK shell.

Safety Evaluation Division has expressed the need for a tool to evaluate emergency operating procedures at CANDU plants. The most effective tool would be an interactive computer simulation program. As a first step in obtaining this tool, the simulation language (or "shell") SIMAK is to be purchased and complete documentation is to be prepared. Subsequently, a contract will be funded to have the specific modules of a CANDU 600 MW reactor written and installed in SIMAK.

The purchased program will be used in preparing an analysis tool: an interactive computer simulation of a CANDU 600 MW reactor.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$15,000.00	$0.00	$15,000.00

Contract Completed: N.A.

COMMENTS: Negotiations with AECL in progress.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.1.25 **A Tutorial on Expert Systems and Their Use

Category - NEW File Number: 34-2-4-42
Contractor - Loecus Informatics Inc. (D. Wilson)
Ottawa, Ontario

A project is proposed which would provide a short course on Expert Systems (ES). This course would cover: the properties of ES, their limitations, and their usefulness.

Licensees are known to be investigating the possible use of ES in reactor control room as operator aids during emergency situations. In anticipation of possible licensee submissions on the topic of ES, AECB staff are familiarizing themselves with the topic. One effective way of transmitting the required information on the topic is by holding a short course.

The results of the project would be used in the continuing effort of the AECB to familiarize themselves with the topic of ES.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$6,000.00	$0.00	$6,000.00
Actual Spending:	$0.00	$6,125.00	$0.00 (Estimate)	$6,125.00 (Estimate)

Contract Completed: Yes

COMMENTS:

RESULTS: A series of five lectures was given, providing an introduction to expert systems.

EVALUATION: Post Project Evaluation in progress.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

MISSION OBJECT 2 - HEAVY WATER PRODUCTION PLANTS

84.2.2 Flammability and Detonability Limits of Hydrogen Sulphide

Category - 1* File Number: 34-3-2-4
Contractor - National Defence (I. Moen)
Ralston, Alberta

A study is under way to measure the flammability and detonability limits of hydrogen sulphide.

In the event of a release of hydrogen sulphide gas from a heavy water production plant, current operating procedures call for the deliberate ignition of the cloud. The appropriateness of such a procedure is being evaluated as part of the on-going review of heavy water production plants, and for that evaluation it is necessary to know the flammability and detonability limits of hydrogen sulphide.

The results will be used in evaluating the possibility of an unconfined vapour cloud explosion of a released cloud of hydrogen sulphide.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$156,000.00	0.00	$0.00	$156,000.00
Actual Spending:	$156,000.00	$0.00	$0.00	$156,000.00

Contract Completed: Yes

COMMENTS: Awaiting Phase II report.

RESULTS: The results of Phase I of an investigation directed towards quantifying the explosion hazards of hydrogen sulphide in air are described. The first phase is focussed on detonation in free hydrogen sulphide/air clouds. Detonation properties, including velocity and pressure, have been calculated and compared with experimental results. The observed detonation structure together with critical tube diameter tests are used to assess the detonability of hydrogen sulphide/air mixtures relative to hydrogen and common hydrocarbon gases. Detailed chemical kinetic modelling of hydrogen sulphide combustion in air has been performed to correlate the detonation cell size data and to determine the influence of water vapour on the detonability of hydrogen sulphide in air. Calculations of the blast wave properties for detonation of a hydrogen sulphide/air cloud provide the data required to assess the blast effects of such explosions.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.2.1 Probabilistic Consequence Assessment of H_2S Releases - Addendum and Summary

Category - 1* File Number: 34-3-2-3
Contractor - Monserco Ltd. (C. Baynes)
Mississauga, Ontario

It is proposed to fund a project summarize and update the results of a series of projects on probabilistic consequence assessment of heavy water production plants.

In the past few years, several projects have been funded to investigate the consequences following a postulated release of hydrogen sulphide gas at a heavy water production plant. Since the studies were initiated, new information has become available that is relevant to the calculations performed. Further, licensees have commented on certain technical aspects of the projects. A synthesis of the projects with the new information and the peer review would provide a complete overview of the final results of the consequence assessments.

The results of the project would be used in the continuing review of the safety of heavy water production plants.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$14,000.00	0.00	$0.00	$14,000.00
Actual Spending:	$14,000.00	$0.00	$0.00	$14,000.00

Contract Completed: Yes

COMMENTS:

RESULTS: The project updated previous work and summarized the results of the series of contracts on the topic. Probability-consequence curves were calculated for various postulated release quantities of H_2S.

EVALUATION: Post Project Evaluation in progress.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

MISSION OBJECT 3 - URANIUM MINES AND MILLS

84.3.13 Thoron Daughters in an Underground Mine Environment

Category - 1* File Number: 34-4-2-16
Contractor - DSMA Atcon Limited (Dr. A. Robertson)
Toronto, Ontario

It is proposed to determine the mass and activity median diameter of carrier aerosols for attached Pb-212, and the unattached fraction of the total alpha energy of Pb-212, in a uranium mine in the Elliot Lake region, during the performance of the following mining operations: a) for trackless mining: loading explosives, drilling, mucking; and b) for track type mining: loading explosives, drilling, slushing.

This work is proposed because the conversion factor between intake of potential alpha energy and absorbed dose to mine personnel depends on the unattached fraction of the total alpha energy of Pb-212 atoms (in a thoron daughter containing environment) and the activity median diameter of the carrier aerosols of the attached Pb-212 atoms. These characteristics of the mine atmosphere are not well known.

It is anticipated that this work will be used to provide improved dose estimates for mine personnel exposed to thoron daughters in the Elliot Lake Region.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$61,000.00	0.00	$0.00	$61,000.00
Actual Spending:	$61,171.77	$0.00	$0.00	$61,171.77

Contract Completed: Yes

COMMENTS:

RESULTS: In the track mine, the aerosol concentration ranges from 3×10^4 to 7×10^4 cm^{-3}, with a count median diameter of about 55 nm. In the trackless mine, the aerosol concentration ranges from 8×10^4 to 30×10^4 cm^{-3}, with a count median diameter varying from 32 to 94 nm. The activity median diameters were 54, 50, 59 and 72 nm for Po-218, Pb-214, Bi-218 and Pb-212 respectively in the track mine, and 73, 70, 85 and 100 nm for Po-218, Pb-218, Bi-218 and Pb-212 respectively in the trackless mine. The unattached fractions for short-lived radon and thoron daughters were in the range of 1 to 3%.

EVALUATION: The measurements of the size distribution of the attached 222-Rn decay products and of the attached 212-Pb were carried out satisfactorily. Owing to the inability of the main contractor to complete all of the tasks, the

sizes of unattached fractions of 222-Rn decay products and 212-Pb were not determined. A small follow-up contract (Project No. 85.3.7) was issued and the determination of the sizes of the unattached fractions was carried out satisfactorily. The dose per unit exposure which serves as a basis for the present regulatory limits is calculated assuming an activity median aerodynamic diameter of 0.1 micron. The size distributions of aerosols (to which radon or thoron decay products are attached) in Canadian uranium mines as observed in this study are similar to those. Therefore, no revision of these regulatory limits on exposure is required on the basis of aerosol size distribution. Owing to the need for a follow-up contract, the value for money was less than originally projected.

PUBLICATIONS:

1) INFO 0164, "Comparison of Radon and Thoron Daughter Behaviour in Two Underground Uranium Mine Environments".

2) "Underground Measurements of Aerosol and Radon and Thoron Progeny Activity Distributions", A. Khan, F. Bandi, C.R. Phillips, P.J. Duport, Proceedings of the American Chemical Society Symposium on Radon and Its Decay Products: Occurrence, Properties and Health Effects, New York, 1986.

REVIEW PANEL ACTIVITIES:

84.3.22 Feasibility Study of the Dissolution Rates of Uranium Ore Dust, Uranium Concentrates and Uranium Compounds in Simulated Lung Fluid

Category - 1* File Number: 34-7-2-37
Contractor - Becquerel Laboratories Inc. (Dr. R. Robertson)
Mississauga, Ontario

It is proposed to determine experimentally the air concentration, the activity size distribution and the solubility of airborne uranium-bearing aerosols in all Canadian uranium mines, mills, refineries and fuel fabrication plants.

This work is proposed to quantify the hazard presented by airborne radioactive long-lived materials in the concerned facilities. The parameters necessary to calculate the committed effective dose equivalent from exposure data must be determined (activity concentration in air, size distribution, radionuclide make-up and dissolution rate in simulated lung fluid) in order to evaluate quantitatively this specific radiation hazard.

It is anticipated that this study will indicate the magnitude of the long-lived dust risk in uranium producing/manufacturing industries. It will also likely aid in substantiating any forthcoming regulation and will facilitate interpretation of bioassay data for the purpose of radiation protection of the workers at these facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$49,000.00	0.00	$0.00	$49,000.00
Actual Spending:	$43,549.40	$5,342.10	$0.00	$48,891.50

Contract Completed: Yes

COMMENTS:

RESULTS: A flow-through apparatus has been devised to study the dissolution in simulated lung fluid of aerosol materials associated with the Canadian uranium industry. The apparatus has been experimentally applied over 16-day extraction periods to samples from Elliot Lake and Mid-Western uranium ores. It was incidentally found that the elemental composition of the ores studied varies significantly with particle size, the radionuclide-containing minerals and several extractable stable elements being concentrated in the smaller size fraction. Samples of the refined compounds uranium dioxide and uranium trioxide were submitted to similar 16-day extraction experiments. Two aerosol samples on filters were also studied. A cascade impactor sample collected from the yellowcake packing area of an Elliot Lake mill was extracted over a 16-day period. Similarly, extraction from an open face filter sample collected in a fuel fabrication plant was performed. Recommendations were made with regard to further work of a research nature which would be useful in this

area. Recommendations are also made on sampling methods, analytical methods and extraction conditions for various aerosols of interest which are to be studied in a work of broader scope (85.3.6) designed to yield meaningful data in connection with lung dosimetry calculations.

EVALUATION: The feasibility study itself was a success in that the apparatus developed and used was simple, reliable, and versatile. Additionally, the analytical techniques selected and used for radionuclide separation, recovery and analysis were reliable and of sufficient sensitivity for performing larger-scale dissolution rate studies on aerosols collected from uranium mines, mills, fuel fabrication plants, and refineries. The work performed has clearly indicated the differing in vitro solubility rates of various uranium compounds in simulated lung fluid and has indicated where additional information is needed. The contractor has suggested how some of this information may be acquired. Moreover, the contractor performed efficiently, providing useful information by performing work beyond the scope of the contract, without additional cost to the AECB. Results of this feasibility study will have a direct impact in the design of the full scale project entitled: "Physical Characteristics and Solubility of Long Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities" (85.3.6).

PUBLICATIONS:

1) INFO 0205, "Feasibility Study of the Dissolution Rates of Uranium Ore Dust, Uranium Concentrates and Uranium Compounds in Simulated Lung Fluid".
2) "Contribution of Airborne Radioactive Long-Lived Dust to the Total Radiation Doses Received by Uranium Mine and Mill Workers", P. Duport, S. Ching, K.P. Ho, F. Horvath, E. Rabin and H. Stocker (paper to be presented at CRPA Annual Conference, 1987, Saskatoon). Results from a previously completed project entitled: "Determination of the Contribution of Long-Lived Dust to the Committed Dose Equivalent Received by Uranium Mine and Mill Workers in Elliot Lake Area" (INFO 0167) are also included in this publication.

REVIEW PANEL ACTIVITIES: During the course of the project, the panelists made numerous suggestions and gave valuable advice on the design and development of the equipment and techniques to be used for the dissolution process. The panelists also provided insightful interpretations of the results obtained from the data on the solubility rates. The panelists reviewed and accepted the draft final report and attended the debriefing meeting at the AECB headquarters. Several key points were raised by the panelists as a result of the feasibility project and these points will be investigated in the full-scale project 85.3.6. (Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities).

85.3.3 Assessment of the Performance of Personal Radon Daughter Dosimeters

Category - 1* File Number: 34-4-2-26
Contractor - Atomic Energy of Canada Limited
(Dr. R.G.C. McElroy, Dr. J.R. Johnson)
Chalk River, Ontario

It is proposed to carry out an assessment of the past performances of personal radon daughters dosimeters, based on Canadian and world-wide experience with them. This will be done by means of a critical review of the relevant literature and by interviews with scientists, engineers, first-line supervisors and miners themselves.

The assessment will provide the basis for a forthcoming AECB staff review of the performance characteristics and advantages and disadvantages of personal radon daughters dosimeters (both active and passive) covering their development and use in uranium mines, in other mines and in other applications over the past decade.

It is anticipated that this study will, in addition to the technical assessment, make recommendations on whether further R & D financial support (by the AECB or other government agencies) of personal radon daughter dosimeters is warranted and should continue and, if so, in what specific technological areas. The study and later staff review will also provide guidance to the Uranium Mine Division on the degree to which personal radon daughter dosimeters should be used by licensees for individual exposure estimation of workers in Canadian uranium mines and mills or whether they should be used at all.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$42,000.00	0.00	$0.00	$42,000.00
Actual Spending:	$41,820.00	$0.00	$0.00	$41,820.00

Contract Completed: Yes

COMMENTS:

RESULTS: On the basis of an extensive review of the recent literature concerning passive radon daughter dosimeters and interviews with researchers in the field, the contractors have reached the following conclusions: (1) Passive dosimeters for measuring radon are available and reliable. (2) There does not presently exist an acceptable passive dosimeter for radon daughters. There is little if any hope for the development of such a device in the foreseeable future. (3) They are pessimistic about the potential of "semi-passive dosimeters" but are less firm about stating categorically that these devices cannot be developed into a useful radon daughter dosimeter. This report documents and justifies these conclusions. It does not address the question of the worker's acceptance of these devices because, at the present time, no device is sufficiently advanced for this question to be meaningful.

EVALUATION: The contractor successfully completed the tasks set out in the work statement. AECB staff who reviewed the report re-affirmed the conclusions arrived at in the report, with respect to future R & D effort by the AECB on personal radon daughter dosimeters. This work has provided the AECB Research Branch with valuable direction concerning which dosimeter development studies are worth supporting and which are not. It has also provided guidance to the Uranium Mine Division and to the Radiation Protection Division on the application of dosimeters to the assessment of radon daughter exposures.

PUBLICATIONS: INFO 0184, "Passive Radon Daughter Dosimeters".

REVIEW PANEL ACTIVITIES:

85.3.6 Physical Characteristics and Solubility of Airborne Long-Lived Dust in Uranium Producing and Manufacturing Facilities

Category - 1

It is proposed to determine experimentally the size distribution, the activity distribution and the solubility of airborne uranium-bearing aerosols in all Canadian uranium mines and mills.

This work is proposed to quantify the hazard presented by airborne radioactive long-lived materials in the concerned facilities. The parameters (size distribution, activity distribution, radionuclide composition and dissolution rate in simulated lung fluid) which are necessary to calculate the committed effective dose equivalent from exposure data must be determined in order to evaluate quantitatively this specific radiation hazard.

It is anticipated that this study will indicate the magnitude of the risk of long-lived dust in uranium producing and manufacturing industries. It will also provide supporting information for any forthcoming regulation on long-lived dust and will facilitate interpretation of bioassay data for the purpose of radiation protection of the workers at these facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$40,000.00	$100,000.00

Contract Completed: No

COMMENTS: The work statement for this project has been prepared following the completion of the feasibility study 84.3.22.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: The review panel reviewed the work statement and found it to be acceptable.

85.3.7 Analysis of Factors Affecting Aerosol Measurement in Mines

Category - 1* File Number: 34-4-2-16
Contractor - Chemical Engineering Research Consultants Ltd.
(Prof. C.R. Phillips)
Toronto, Ontario

It is proposed to determine the size distribution and AMAD of the attached fraction of radon and thoron progeny in uranium mine atmospheres, when the measurements are taken in the presence of significant amounts of unattached radon/thoron progeny. The analysis will be conducted on experimental data already available using the most recent theories and computational tools in the field of aerosol physics. Due to the stochastic nature of radioactive decay and to the nature of the classical Tsivoglou-Thomas equations, concentrations of radon/thoron short-lived daughters are determined with large uncertainties, making it difficult to measure the unattached fractions from air samples taken on reference filters and on filters placed downstream of wire screen aerosol collectors. The combined use of Tsivoglou-Thomas equations and of gross alpha counts observed on filters will help in reducing the uncertainties on the dimensions and unattached fraction of radioactive aerosol in mine atmospheres.

Radon and thoron progeny size distribution and AMAD are computed from gross alpha activity measured on air samples collected on reference filters and on filters placed downstream of special aerosol collectors (diffusion batteries). The new approach is to take into account in the computation the measured amount of unattached fractions when determining the size distribution and the AMAD of the attached fraction of the radioactive aerosol because the attached and unattached fraction behave differently in diffusion batteries. The new calculation will result in a more accurate determination of the size distribtuion and AMAD of the attached fraction and of the unattached fraction.

The results of this study will be used in current lung dosimetric models to calculate more accurately the exposure-to-dose conversion factors in uranium mine situations.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$6,000.00	0.00	$0.00	$6,000.00
Actual Spending:	$6,000.00	$0.00	$0.00	$6,000.00

Contract Completed: Yes

COMMENTS: Follow-up to project 84.3.13.

RESULTS: Data from measurements of unattached and attached radon/thoron daughters obtained in two uranium mines were analyzed in detail by a reliable and thorough contractor. The main conclusions of this study are: a) unattached fraction smaller than 10% does not affect significantly the

determination (by means of diffusion batteries) of the AMAD of the attached fraction; b) the calculation of the unattached fraction from counts on the wire screen and reference filter yields smaller values than from counts on reference and back-up filter; and c) theoretical determination of the unattached fraction is very sensitive to the age of the air. The hybrid attachment theory (combination of kinetic and diffusion theories) describes the attachment mechanism best. The findings of the study will be used to select the most appropriate procedures for measuring accurately the concentration of radon and thoron decay products in the air; they also indicate to what extent the unattached fraction warrants corrections for the determination of aerosol size distribution by means of diffusion batteries.

EVALUATION: Post Project Evaluation under way.

PUBLICATIONS:

1) INFO 0187, "Analysis of Factors Affecting Aerosol, Unattached Fraction and Radon Progeny Measurements in Mines".
2) "Unattached Fractions and Error Analysis of Radon and Thoron Progeny Measured by the Wire Screen Method in a Canadian Uranium Mine", A. Khan, C.R. Phillips, P. Duport, Radiation Protection Dosimetry (accepted for publication).
3) "Underground Measurements of Aerosol Radon and Thoron Progeny Activity Distributions", A. Khan, F. Bandi, C.R. Phillips, P.J. Duport, Proceedings of the American Chemical Society Symposium on Radon and Its Decay Products: Occurrence, Properties and Health Effects, New York, 1986.

REVIEW PANEL ACTIVITIES:

85.3.8 An Assessment of the Environmental Impact of Uranium Mining in Northern Saskatchewan

Category - NEW File Number: 34-5-2-30
Contractor - IEC Beak Consultants Ltd.
Mississauga, Ontario

NO PROJECT SUMMARY PREPARED.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$16,800.00	$1,200.00	$0.00	$18,000.00
Actual Spending:	$16,800.00	$1,200.00	$0.00	$18,000.00

Contract Completed: Yes

COMMENTS: This joint project between Environment Canada and AECB, in which the AECB was the minor contributor, was completed in 1983. The FY 86/87 contribution was to assist with the publication of the final (DOE) report.

RESULTS:

EVALUATION:

PUBLICATIONS: EPS2/MM/1: "An Assessment of the Radiological Impact of Uranium Mining in Northern Saskatchewan".

REVIEW PANEL ACTIVITIES:

85.3.10 **Determination of Radon and Thoron Fluxes in Uranium Mines (Ontario)

Category - 1 File Number: 34-4-2-29
Contractor - Denison Mines Ltd. (Mr. J.L. Chakravatti)
Elliot Lake, Ontario

It is proposed to measure the flux of radon and thoron gases emitted per unit surface area of stopes, airways and passageways of an underground uranium mine.

The AECB has recently completed a research project (84.3.4) aimed at developing a computer model of underground mine ventilation networks. That model is made up of two parts. The first part of the model is used to determine the patterns of air circulation throughout the mine. The second part is designed to predict the concentrations of short-lived airborne radionuclides at given places of the ventilation network, for radiation protection purposes. The accuracy of those predictions depends on the quality of the information available on the characteristics of the sources of radon and thoron gases.

It is anticipated that systematic and accurate measurement of the characteristics of radon and thoron sources will enable the Board to use the computer ventilation model to its full capabilities, and to carry out studies and verifications required by the Uranium Mine Division. (See 85.3.11.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$70,000.00	$10,000.00	$80,000.00
Actual Spending:	$0.00	$63,278.00	$44,192.00 (Estimate)	$107,470.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. All sampling locations have been chosen. Sampling and counting procedures have been defined, and their adequacy and sensitivities tested. An increase in radon concentration between two distant cross sections of mine galleries have been measured.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.3.11 **Determination of Radon Fluxes in Uranium Mines (Saskatchewan)

Category - 1 File Number: 34-4-2-30
Contractor - Senes Consultants Ltd. (Mr. G.G. Case)
Willowdale, Ontario

It is proposed to measure the flux of radon gas emitted per unit surface area of stopes, airways and passageways of an underground uranium mine. (In contrast to uranium mines in the Elliot Lake region of Ontario, there are no sources of thoron gas in uranium mines in Saskatchewan.)

The AECB has recently completed a research project (84.3.4) aimed at developing a computer model of underground mine ventilation networks. That model is made up of two parts. The first part of the model is used to determine the patterns of air circulation throughout the mine. The second part is designed to predict the level of short-lived airborne radionuclides at given places of the ventilation network, for radiation protection purposes. The accuracy of those predictions depends on the quality of the information available on the characteristics of the sources of radon gas.

It is anticipated that systematic and accurate measurement of the characteristics of radon sources will enable the Board to use the computer ventilation model to its full capabilities, and to carry out studies and verifications required by the Uranium Mine Division. (See 85.3.10.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$45,000.00	$13,000.00	$58,000.00
Actual Spending:	$0.00	$24,654.00	$34,123.00 (Estimate)	$58,777.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. Sampling locations have been selected. Air sampling and counting procedures have been defined and tested. Two sampling programs have been conducted at the site.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.3.12 Factors Influencing the Use of Respirators in Uranium Mines

Category - 1* File Number: 34-7-2-20
Contractor - Atomic Energy of Canada Limited (Dr. F. Kalos)
Chalk River, Ontario

It is proposed to implement a full statistical analysis of the responses to the 1984 user survey conducted as part of the research project entitled "Study of Efficiency and Current Use of Respiratory Protective Devices" (Report INFO-0144). This study will describe the influence of different factors (such as job description, experience, comfort) on respirator usage, and how the different comments received correlate with use or non-use.

The original respirator study included a user survey that quantified the extent of proper use, and contained questions about several factors that may influence respirator use. The responses were tallied and described briefly in Section 3 of the report, but the scope of the research contract did not allow for a full statistical analysis of these data. This statistical analysis will identify the major reasons why some miners use the respirator (AIRSTREAM AH-5) correctly during most of the workshift, while others do not.

It is anticipated that the findings of this study will provide information pertinent to AECB discussions with mining companies concerning obtaining credits for respirator use.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$5,000.00	0.00	$0.00	$5,000.00
Actual Spending:	$5,000.00	$0.00	$0.00	$5,000.00

Contract Completed: Yes

COMMENTS:

RESULTS: A statistical analysis was performed of the responses to a users' survey by uranium miners who were voluntary users of a helmet-type powered respirator. The analysis concludes that the duration of visor-lifting was lognormally distributed with a geometric mean of 1.15 hours. Use depends strongly on job category. Many of the factors examined by the survey were use-dependent instead of use-determining, or had no effect on proper use. Many of the miners stated the respirator could not cope with their hard work; its visor fogged up. The very diversity of these comments prevented confirming by statistical means an association between fogging and use. Recommendations on users' surveys are given.

EVALUATION: The contractor successfully completed the tasks set out in the work statement. The report can provide direct and immediate guidance to workers (as required by the uranium mining companies, by the AECB or as suggested by the respirator manufacturer) on the proper and preferred uses of the respirator. The AECB received good value for money from this project. A follow-up post project evaluation will be issued in July 1987.

PUBLICATIONS: INFO 0193, "Study of Factors that Influence the Use of Respirators in Uranium Mines".

REVIEW PANEL ACTIVITIES:

85.3.13 Characterization of Long-Lived Dust at a Saskatchewan Mine-Mill Facility

Category - 1* File Number: 34-4-2-31
Contractor - CANMET Elliot Lake Laboratory (Dr. J. Bigu)
Elliot Lake, Ontario

It is proposed to determine experimentally, using reference-type cascade impactors, the size distribution, activity distribution and radionuclide composition of airborne long-lived dust at a Saskatchewan uranium producing facility, and to compare, in the field, the performance of several aerosol sampling instruments. This is a joint AECB-EMR project. The work will be carried out by EMR, as part of a larger project planned for this facility.

This project is proposed because, in order to determine the adequacy of current practices used for evaluating the radiological and chemical risks to individuals exposed to airborne particulate material containing uranium and its decay products, it is necessary to know the physical parameters that govern their inhalation, as well as their deposition in, and removal from, the lung. It is also necessary to compare the information given by every type of instrument used in the field which is used to determine workers' exposure to airborne long-lived dust.

It is anticipated that the measured particle size distribution, activity distribution and radionuclide composition will make it possible to determine the ALI and DAC specific to the considered site. The field comparison between all the measurements of concentrations of long-lived dust in the air, taken with a variety of instruments, or the individual exposures resulting from such concentrations and the measurements obtained from a reference calibrated instrument will allow the determination of a reliable standard measurement method.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$6,000.00	$7,000.00	$0.00	$13,000.00
Actual Spending:	$8,587.12	$4,408.55	$0.00	$12,995.67

Contract Completed: No

COMMENTS: Final report in preparation. The preliminary results obtained from the measurements indicate that the physical dimensions of airborne radioactive dust are similar to those found in Elliot Lake facilities (reported in AECB INFO 0167).

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.3.1 Field Intercomparison of Instruments Used in the Determination of Size Distribution of Airborne Particles in Canadian Uranium Mines and Mills

Category - 3

It is proposed to perform field intercomparisons of instruments used to determine the size distribution of airborne particulate matter in all Canadian uranium mines and mills. Dust sampling instruments currently used by licensees for measuring uranium-bearing dust concentrations in the air will be tested against, and compared to, reference cascade impactors. Small-size personal cascade impactors will also be tested. The operating costs of current samplers and personal cascade impactors will be evaluated.

This project is proposed because, in keeping with the recommendations of ICRP 30, the AECB is considering the use of a combined formula for calculating the Committed Effective Dose Equivalent received by uranium workers. The combined formula expresses exposure as the sum of the ratios of the exposures to each specific radiation hazard (gamma, radon progeny, thoron progeny, long-lived dust) to their respective annual limit of exposure or their Annual Limit on Intake (ALI). The Annual Limit on Intake for radioactive aerosols is, among other factors, a function of the particle size. It is therefore necessary to know the size distribution of the radioactive dust of concern to determine such parameters as ALI, Derived Air Concentrations (DAC) or Committed Effective Dose Equivalent. However, currently used air samplers are designed to measure air concentrations of "respirable dust" (dust that, when inhaled, deposits in the bronchi and alveoli of the lung). The notion of "respirable dust" does not apply to radioactive aerosols: every particle that enters the body (nose, trachea or lung) contributes to the Committed Effective Dose Equivalent. Consequently, it is necessary to determine what uncertainties routine dust samplers introduce in the measurement of exposure to radioactive dust.

It is anticipated that the results of this study will indicate how the dust measurements obtained from currently used instruments, and from a personal cascade impactor, compare with measurements obtained from reference instruments. The influence of the size distribution of dust on instruments used routinely will be determined. This will assist the AECB in drafting guidelines for monitoring techniques and in evaluating codes of practice submitted by licensees.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$20,000.00	$80,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.3.2 **Calibration of Wire Screen Collectors Used in the Measurement of Unattached Fraction of Radon and Thoron Progeny in Air

Category - 1 File Number: 34-4-2-32
Contractor - CERCL Ltd. (Prof. C.R. Phillips)
Toronto, Ontario

It is proposed to calibrate experimentally a variety of wire screen aerosol collectors for measuring the unattached fraction of radon and thoron progeny in air. In addition, the theory and the semi-empirical laws governing aerosol collection and alpha counting characteristics on wire screen collectors will be given.

This project is proposed because the complete deposition in the respiratory tract of the unattached fraction of radon and thoron progeny delivers 10 to 20 times more energy to lung tissue per unit exposure than the attached fraction does. The unattached fraction of radon and thoron daughters is highly variable, ranging from a few percent in diesel-powered areas of uranium mines, to more than 40% in non-mechanized areas and surface installations. Consequently, a complete evaluation of the radiological hazard presented by airborne radioactivity requires the knowledge of the unattached fraction. Wire screen aerosol collectors are the most convenient tools for measuring the unattached fraction; however, the characteristics of their collection efficiency and counting geometry have not been thoroughly investigated.

It is anticipated that the results of the study will fill a gap in knowledge regarding the accuracy of a crucial parameter in the measurement of ultrafine radioactive aerosols. They will also allow the Board staff to interpret more accurately atmospheric radioactivity measurements taken in uranium producing facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$30,000.00	$90,000.00
Actual Spending:	$0.00	$21,426.00	$81,424.00 (Estimate)	$102,850.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. Phase I (literature review) has been completed. Theoretical work regarding the collection and counting efficiency of a wire screen for the measurement of unattached radon and thoron progeny is in progress.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.3.3 Development of a Dosimetry Database for Atomic Radiation Workers in Canada

Category - 2

It is proposed to develop a dosimetry database for Atomic Radiation Workers in Canada. The contractor will design and produce an operational database that contains all necessary information and analytical procedures to permit the AECB to perform statistical and time series analyses of exposure and dose records using the AECB computer system.

This project is being proposed because there has been very little work done to date with respect to analyses of these exposure and dose data. Moreover, exposure and dose data received from the licensees by the AECB are in printed form, a form which is not easily amenable to trend analyses or calculation of statistical parameters. Exposure and dose information in the National Dose Registry is oriented toward individual records with little characterizing information, thus of very little use in identifying and analyzing groups of workers by sector within the nuclear industry, by specific nuclear facility, or by licensee. There will, therefore, be no duplication between the uses of this database and that of the National Dose Registry.

It is anticipated that analyses by AECB staff of the records to be included in the computer database for such workers will enable the AECB to have up-to-date information on the radiological conditions that prevail at the various nuclear facilities and for the various types of occupational groups. Distributions of exposures and doses by occupational group, nuclear facility type, etc., as well as individual and collective long-term exposure and dose trends should become known by these means, along with some information required for further reducing the radiation risks to these groups. The part of the database consisting of the exposure and dose records of uranium mine workers will likely be the first to be analyzed using this computer system.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$40,000.00	$90,000.00

Contract Completed: N.A.

COMMENTS: Project deferred until an internal review of AECB requirements has been completed.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.3.4 **In Vivo Measurements of Thorium-232 Body Burden from Mill Workers of 1950s and 1960s

Category - NEW File Number: 34-7-2-65
Contractor - Atomic Energy of Canada Limited (Dr. J.R. Johnson)
Chalk River, Ontario

It is proposed to measure thorium-232 retained in the lungs of several (up to four) uranium mill workers after their exposure to thorium dust while employed in the production of thorium sulphate and thorium oxide in a plant operating in the late 1950s and through the 1960s. The work histories of the mill workers involved will be obtained from the companies and included in this study.

This study is proposed in order to explore the possibility of detecting thorium-232 retained in the lung of former thorium plant workers after a long period of non-exposure to thorium, and to relate these levels to thorium exposures. It is intended to use this information to ensure that the dose records of uranium mine and mill workers are as complete as possible.

It is anticipated that this work will result in a better understanding of thorium exposures that were encountered in the former thorium production circuit in the production of thorium oxide and thorium sulphate.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$9,000.00	$0.00	$9,000.00
Actual Spending:	$0.00	$5,752.60	$3,472.40 (Estimate)	$9,225.00 (Estimate)

Contract Completed: No

COMMENTS: The final report is being prepared.

RESULTS: The levels of thorium-232 measured in the three volunteers for this project were found to be insignificantly different from background levels. Given these preliminary results, the project was terminated and no dose calculations were performed.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.3.5 **Modified Personal Alpha Dosimeter for Canadian Uranium Mines

Category - NEW File Number: 34-4-2-33
Contractor - Canadian Institute for Radiation Safety (Dr. E. Becker)
Toronto, Ontario

It is proposed to fund the modification of the measuring head of the personal alpha dosimeter developed by the French Atomic Energy Commission and used in some Canadian uranium mines and mills.

The modification is aimed at eliminating, or reducing substantially, spurious measurements of airborne radon and thoron decay products induced by the contamination of the internal parts of the measuring head by ultrafine long-lived radioactive dust particles.

It is anticipated that the modification, if it proves successful, will significantly improve the accuracy and reliability of individual exposure measurements to airborne radioactivity in high grade Saskatchewan uranium mines and mills. (The Department of Energy, Mines and Resources has agreed to a further contribution of $10K for FY 86/87.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$8,000.00	$45,000.00	$53,000.00
Actual Spending:	$0.00	$8,454.00	$44,713.00 (Estimate)	$53,167.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. Prototypes of a modified measuring head have been made and are being tested in the laboratory.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.3.6 **Technical Evaluation of an Instant Working Level Meter

Category - NEW File Number: 34-4-2-34
Contractor - CANMET Elliot Lake Laboratory (Dr. J. Bigu)
Elliot Lake, Ontario

It is proposed to acquire and test, in a laboratory and in the field, a new, lightweight, portable Instant Working Level Meter (IWLM).

Until recently, there were no portable instruments capable of measuring accurately, rapidly, and with an acceptable sensitivity the air concentration of potential alpha energy of radon daughters in mine environments. The only other known portable Instant Working Level Meter is produced in the U.S.A. However, this latter device is sensitive to gamma radiation, is highly inaccurate when concentrations of radon daughters are lower than 0.1 WL (the equivalent, in concentration, of 1/3 of the mean annual permissible limit), and weighs about 12 lbs. The proposed new instrument has a lower limit of detectability of 0.005 WL, is insensitive to gamma radiation, weighs about 1.8 kg (4 lbs.), and is routinely used in uranium mines in Africa and Europe.

It is anticipated that this project will provide the AECB mine inspectors with a suitable tool for monitoring, quickly and conveniently, levels of airborne radioactivity in uranium mine and mill workplaces.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$33,000.00	$0.00	$33,000.00
Actual Spending:	$0.00	$32,815.52	$0.00	$32,815.52

Contract Completed: No

COMMENTS: Final report in preparation. The acquired Instant Working Level Meter has been tested in a radon calibration facility at the CANMET Elliot Lake Laboratory, at the radon calibration facility of the U.S. Bureau of Mines, Denver, Colorado, and under actual underground mine conditions.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

MISSION OBJECT 4 - OTHER FUEL CYCLE FACILITIES

84.4.1 **Demonstration of the Feasibility of Directly Dating Quartz

Category - 1 File Number: 34-5-2-59
Contractor - Dr. A.L. Odom, Florida State University
Tallahassee, Florida

Using samples of quartz from rocks of known age it is proposed to examine the feasibility of directly dating the quartz using a technique involving electron spin resonance.

This study is proposed because, in selecting the site for any nuclear facility, it is important to know whether or not the earth's crust in the vicinity of the proposed site is relatively stable. The presence of earthquakes is an obvious indicator of instability. However, some seismically active areas have been known to be quiescent for as long as 2000 years before major seismic activity was renewed yet, in Canada, earthquake records go back a maximum of only 450 years. To help obtain a more accurate estimate of the tectonic conditions, the minimum age of the youngest fault movement should be known.

If the results of using electron-spin resonance to date quartz are positive then the intention would be to indicate to licensees, in the form of guidelines, that, where appropriate, fault-filling quartz be dated.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$15,000.00	$50,000.00	$0.00	$65,000.00
Actual Spending:	$0.00	$38,555.00	$10,290.00 (Estimate)	$48,845.00 (Estimate)

Contract Completed: No

COMMENTS: A breakthrough in the technology has been made in that quartz from older rocks has been found to yield stronger ESR signals than quartz from younger rocks.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S2: The panel was only recently formed, and has not, as yet, been required to review any material.

84.4.3 Transfer Coefficients in the Feed/Poultry/Egg Pathway

Category - 1* File Number: 34-14-1-2
Contractor - Research Foods (1976) Limited
(Ms. D. Pryde, Mr. A. Gawhari)
Downsview, Ontario

It is proposed to continue a project in which concentration factors for selected radionuclides are being determined for the feed/poultry/egg pathway.

At present, concentration factors for this pathway are few. Those that are used in such submissions to the AECB as derived release limit calculations have been produced from only a small set of measurements.

These data and concentration factors, as well as related information gained from doing this project, will be used in evaluating the validity and reliability of derived release limit estimations or any other submissions to the AECB where doses to humans have been estimated from pathways analysis.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$43,500.00	0.00	$0.00	$43,500.00
Actual Spending:	$35,060.93	$0.00	$0.00	$35,060.93

Contract Completed: Yes

COMMENTS: Some of the tasks originally described were not performed. This resulted in a reduction in the original estimate.

RESULTS: The concentrations of the radionuclides carbon-14 and tritium, as well as the stable elements, cobalt, ruthenium, strontium, cesium and iodine, were measured in selected components of the feed/poultry/egg pathway. Tritium and carbon-14 were detected at consistent levels in all components, i.e. water, feed, muscle, liver, skin, egg white, shell and egg yolk. On the basis of the preliminary analyses carried out so far, transfer coefficients were found to range from 1 to 2.5 for tritium and 3 to 4 for carbon-14. Of the five stable elements, only strontium was detected in water, feed and, to a limited extent, in bone and egg shell.

EVALUATION:

PUBLICATIONS: Although the work done by the contractor was good, the loss of a critical member of the contractor staff led to the production of a final report which was not suitable for publication in the INFO series.

REVIEW PANEL ACTIVITIES:

84.4.4 Transfer of Radionuclides from Food to Human Milk - A Review

Category - 1* File Number: 34-14-1-4
Contractor - Concord Scientific Corporation (Dr. M. Eaman)
Downsview, Ontario

It is proposed to review available information on the concentration factors for radium, thorium, strontium and iodine in the food/human milk pathway.

At present, concentration factors used for pathways analysis in licensee submissions, such as in derived release calculations, have been produced from only a small set of measurements. The information gathered by this project will indicate whether a significantly larger data base is available which could also be used.

The information gained from carrying out this review will be used in deciding whether further data should be gathered by the AECB, either on its own or in conjunction with other agencies.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$30,000.00	0.00	$0.00	$30,000.00
Actual Spending:	$29,534.00	$0.00	$0.00	$29,534.00

Contract Completed: Yes

COMMENTS:

RESULTS: The literature review identified 25 elements for which relevant information was available. Of the 25 elements Sr-90, Cs-137 and certain radiopharmaceuticals were the only radioactive species discussed. The only element of the uranium and thorium decay chains for which information was available was Pb-206. Thus, in order to evaluate the contribution of this pathway to the dose commitment to infants, it has been decided to proceed with Phase II (86.4.9) of this project.

EVALUATION: Post Project Evaluation initiated.

PUBLICATIONS: INFO 0192, "The Effects of Radiogenic Heat on Groundwater Flow"

REVIEW PANEL ACTIVITIES: Review Panel S3: Panel members reviewed and supplied comments on the work statement and the draft final report.

84.4.10 Determination of Concentration Factors - Game Animals

Category - 1* File Number: 34-14-1-5
Contractor - MacLaren Plansearch Inc. (Mr. T. Wheaton)
Toronto, Ontario

It is proposed to complete the determination of concentration factors in the soil/forage/moose pathway for selected radionuclides of the uranium and thorium decay chains.

As moose form part of the diet of some people in the Elliot Lake region, there is a need to know the concentration factors for this pathway. Currently, concentration factors for this food/animal pathway are not available and there is no information as to the significance of the contribution of this pathway to dose.

The data and concentration factors, as well as the related information gained from this project, will be used in evaluating the validity and reliability of derived release limit estimations or any other submissions to the AECB where doses to humans have been estimated from pathways analysis.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$35,000.00	$20,000.00	$0.00	$55,000.00
Actual Spending:	$35,040.00	$23,830.00	$0.00 (Estimate)	$58,870.00 (Estimate)

Contract Completed: No

COMMENTS: Final report under review.

RESULTS: The results from this project indicate that the concentrations of radium-226, uranium, thorium, lead-210 and polonium-210 are very low in the tissue samples of moose taken from the Serpent River Basin. It has also been found that the differences between radionuclide concentrations in control and study samples are statistically not significant. The values of concentration ratios, calculated for only radium-226, suggest that the forage/moose pathway is not a pathway that needs to be included when calculating doses to human resulting from uranium mine-mill tailings operations in the Elliot Lake area.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S3: The panel on Environmental Pathways was not constituted until after the commencement of this project. However, the panel reviewed and have provided comments on the draft final report.

84.4.17 Transfer of Radionuclides from Food to Human Milk

Category - 2

It is proposed to determine the concentration factors for radium, thorium, strontium and iodine in the pathway from food to human milk.

At present, concentration factors for this pathway are practically non-existent. Those that are used in license submissions, such as in derived release calculations, have been produced from only a small set of measurements. The information gathered by this project will aid in determining the validity of currently used concentration factors and provide an indication of their reliability.

These data and concentration factors, as well as the information gained from doing this project, will be used in evaluating the validity and reliability of derived release limit estimations or any other submissions to the AECB where doses to humans have been estimated using this pathway.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$10,000.00	$90,000.00	$0.00	$100,000.00

Contract Completed: N.A.

COMMENTS: Awaiting results from 86.4.9.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S3 (Planned)

85.4.4 A Review of Financial Assurance Mechanisms

Category - 3

A project is proposed which would survey currently available methods for providing financial assurance relating to the costs of decommissioning nuclear facilities.

The AECB wishes to ensure that funds are available to pay the costs of decommissioning nuclear facilities. As yet, it is not clear which method or combination of methods is appropriate for the various nuclear facilities.

The results of the study would provide guidance to the AECB in developing appropriate requirements for financial assurance mechanisms which are tailored to specific nuclear facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$20,000.00	$0.00	$20,000.00

Contract Completed: N.A.

COMMENTS: This project will be cancelled due to limited availability of funds and the eventual decision of the proponent to carry out the work in-house.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.4.10 Geological Evidence of Seismicity - Charlevoix

Category - 1 File Number: 34-5-2-28
Contractor - Laval University (Dr. J-Y Chagnon)
Ste-Foy, Quebec

It is proposed that field investigations be undertaken in the Charlevoix, Quebec, earthquake area to look for, document, and evaluate the kinds of land forms, structures in unconsolidated sediments, and changes in sedimentary layers which have been identified elsewhere and have been interpreted as being generically associated with earthquakes.

This study is proposed because the Charlevoix area has been the site of some of eastern Canada's largest earthquakes, yet no studies have been conducted there to look for geological evidence of these events. Therefore, this study, if successful, will provide geological information to supplement the existing seismic data and enable evaluating the nature and periodicity of both historic and pre-historic earthquakes. Because of the coexistence of geologic and seismic data, it would also provide information for estimating seismic risk in areas being considered for nuclear facilities. The study which would cost a total of $175K over the next three years would be carried out in conjunction with the Geological Survey of Canada and the Earth Physics Branch.

The results of this study are intended to be used both in the formulation of guidelines and for evaluating information from licensees regarding estimates of seismic risk to nuclear facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$56,000.00	$40,000.00	$30,000.00	$126,000.00
Actual Spending:	$0.00	$32,402.00	$67,816.00 (Estimate)	$100,218.00 (Estimate)

Contract Completed: No

COMMENTS: Structures inferred to be seismically induced have been identified and documented but further analysis is required before any definitive conclusions can be drawn.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S2. This panel has only recently been formed and has not yet been required to review any material.

85.4.14 Stress Measurements in Eastern Ontario - Phase II

Category - 1* File Number: 34-5-4-0
Contractor - Ontario Hydro (D. McKay)
Toronto, Ontario

It is proposed to continue the work done in 1984/85, by deepening three existing holes at the Roblindale quarry and measuring stresses in the underlying Precambrian.

This study, also to be conducted in cooperation with Ontario Hydro at a cost of about $50K, is proposed to determine if the stresses in the Precambrian rocks there differ from the stresses in the overlying rocks as they do at Darlington. Additional studies in future years may bring the total cost to about $250K.

The results of this study are intended to provide additional information on regional tectonic conditions as well as to indicate whether or not the stress conditions beneath the Darlington Generating Station are unique. If the results from Roblindale suggest that the stress conditions are Darlington are unique, then there may be a need to re-evaluate the geological conditions relevant to Darlington.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$35,000.00	0.00	$0.00	$35,000.00
Actual Spending:	$14,984.54	$0.00	$0.00 (Estimate)	$14,984.54 (Estimate)

Contract Completed: No

COMMENTS: Work completed. Awaiting final report.

RESULTS: Preliminary results indicate that stress appears to be normal to pop-ups and does not appear to change orientation in going from Precambrian to Paleozoic.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S2: A first draft has been submitted and has, in turn, been sent to one panel member. A new panel member is being added and he, too, will be asked to review the draft.

85.4.15 Transfer Parameters: Feed-Beef Pathway

Category - 1

It is proposed to determine the transfer parameters for selected radionuclides in the ingestion to beef pathway.

Transfer parameters for the feed to beef pathway either do not exist or have not been determined from statistically significant numbers of samples. Because of this lack of information, dose calculations are made using default values that in some cases are based on a single measurement, or are the mean results that range over two orders of magnitude.

The data and transfer parameters, as well as the related information gained from the project, would be used in evaluating the validity and reliability of derived release limit estimations or any other submissions to the AECB where doses to humans have been estimated from pathways analysis.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$0.00	$40,000.00

Contract Completed: N.A.

COMMENTS: Cancelled at the request of HPES because a search of available data on related parameters indicated that some information does exist. In view of this, it was felt that a research project would not be warranted at this time and that allocation of funds to matters of higher priority would be more appropriate.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.4.1 **Stress Measurements in Southern Ontario - Phase 3

Category - 1 File Number: 34-5-4-0
Contractor - Ontario Hydro (D. McKay)
Toronto, Ontario

It is proposed to continue the stress measurement program in the Roblindale Quarry by, among other things, measuring the three-dimensional state-of-stress at fairly shallow depths as well as at a depth of one to two kilometres.

This study, which would continue to be carried out with Ontario Hydro, is proposed in order to gather further information relevant to assessing seismic risk in eastern Canada. The information from this and other related studies, such as that being undertaken in the Charlevoix seismic zone, are needed in order to acquire a reliable data base (other than seismic data themselves) and a far more complete understanding of conditions and characteristics which, respectively, may lead to, and result from, earthquake activity.

It is anticipated that the results of this, and related studies, will eventually be used both for establishing guidelines, and evaluating claims made by licensees, germane to seismic risk.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$40,000.00	$30,000.00	$30,000.00	$100,000.00
Actual Spending:	$0.00	$37,500.00	$0.00 (Estimate)	$37,500.00 (Estimate)

Contract Completed: No

COMMENTS: Work completed. Awaiting final report.

RESULTS: Preliminary results indicate that a much clearer picture has emerged to define more precisely the relationship between P-stress and pop-up orientations (see 85.4.14).

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S2: No reports have yet been received for distribution to the Panel.

86.4.2 Neotectonic Conditions in Eastern Canada - Phase I

Category - 2

It is proposed to participate in, and contribute to, a Federal-Provincial Working Group, the formation of which is being planned to address geologic conditions and, ultimately, the issue of seismic risk in southern Ontario. The group will comprise the Geological Survey of Canada, the Ontario Geological Survey and Ontario Hydro in addition to the AECB. The program to be undertaken by this group is envisaged to last on the order of 5 years and to cost an estimated $2 million. The first study to be commissioned would be a review and analysis of all available geological information dealing with the tectonic setting of southern Ontario and adjacent areas of Canada and the United States.

This program, and AECB participation in it, are proposed because, to date, the assessment of seismic risk has relied solely upon documenting and evaluating historical and current seismic data. This approach has limited value because it is based on the assumption that future earthquakes will occur in areas of past events. Therefore, if a nuclear facility is planned for an area in which earthquakes have not been documented, it is conceivable that the probability of occurrence of a major, disastrous earthquake will be underestimated. Consequently, the design of a nuclear facility to withstand such an earthquake may be inadequate.

It is anticipated that the results of this entire program will provide the AECB with appropriate information for establishing a regulatory position addressing all aspects of seismic risk. The results are also anticipated to be useful in assessing the thoroughness of work undertaken, as well as claims made, by licensees in this particular study area.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$20,000.00	$380,000.00	$400,000.00

Contract Completed: N.A.

COMMENTS: Deferred because other agencies did not have plans in place.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.4.3 Determination of Transfer Parameters: Feed-Pork Pathway

Category - 2

It is proposed to determine transfer parameters in the feed-pork pathway for selected radionuclides.

This project has been proposed because data for calculating transfer parameters for the feed-pork pathway are non-existent.

The data and transfer parameters obtained from this project would be used by AECB staff in evaluating the significance of the feed-pork pathway in the calculation of potential doses to humans.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$20,000.00	$30,000.00	$50,000.00

Contract Completed: N.A.

COMMENTS: Cancelled as requested by HPES because a search of available data on related parameters indicated that some information does exist. In view of this, it was felt that a research project would not be warranted at this time and that the allocation of funds to matters of higher priority would be more appropriate.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.4.4 Transfer Parameters: Inhaled Air-Cow Milk Pathway

Category - 3

It is proposed to undertake a laboratory study to determine the uptake of selected radionuclides in cow milk through the inhalation pathway.

This project is being proposed because at present the data necessary to calculate the transfer parameters for the air to milk pathway in cows are non-existent.

The results obtained of this project would allow AECB staff to determine the significance of the bovine air-milk pathway in dose calculations such as those made in deriving release limits.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$55,000.00	$0.00	$55,000.00

Contract Completed: N.A.

COMMENTS: Cancelled at the request of HPES because information is available (e.g. the study by Zach done at AECL/WNRE) indicating that this pathway is an insignificant contributor to the total dose to humans received from radioactive materials in the effluents of nuclear facilities.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.4.5 **Transfer Parameters - Non-Domesticated Animals

Category - 2 File Number: 34-14-1-10
Contractor - Laurentian University (Dr. F.V. Clulow)
Sudbury, Ontario

It is proposed to determine the radionuclide content of the tissues of non-domesticated animals hunted and trapped in the Serpent River Drainage Basin. Non-domesticated animals shown to be part of the diet of people living in the Serpent River Basin by a previous project (85.4.12) will be selected for this study.

Currently, transfer parameters are not available for these food-animal pathways. When transfer parameters are required, values obtained for domestic animals are sometimes used. There is little information on the significance of the transfer parameters for these pathways in dose calculations.

Transfer parameters and information gained from this project would be used in evaluating the validity and reliability of derived release limit calculations or any other pathways analysis used in calculating dose to humans.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$0.00	$40,000.00
Actual Spending:	$0.00	$15,000.00	$25,000.00 (Estimate)	$40,000.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S3: Panel members were present for the project initiation meeting and made suggestions on the location and number of samples.

86.4.6 **Effect of Soil on Radionuclides in Plants: Literature Survey

Category - 3 File Number: 34-14-1-12
Contractor - Atomic Energy of Canada Ltd. (Dr. S. Sheppard)
Pinawa, Manitoba

It is proposed to conduct a literature survey to determine the effect of soil texture, moisture content, pH and nutritional status (defined as soil nitrogen, phosphorus and potassium content) on the uptake of Pb-210 and Th-232 by plants.

The uptake of radionuclides by plants is affected by the chemical and physical conditions found in the soil and these conditions will vary from one location to another. At present the extent and availability of information concerning the degree to which these conditions affect the uptake of certain radionuclides by plants is not known. AECB staff are therefore not in a position to evaluate the suitability of some default values used for plant radionuclide uptake in calculations of dose to members of the public.

The results of this work would assist AECB staff in the assessment of the suitability of default values for Pb-210 and Th-232 used in dose calculations such as in the derivation of release limits and dose assessments.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$15,000.00	$0.00	$15,000.00
Actual Spending:	$0.00	$12,010.00	$0.00 (Estimate)	$12,010.00 (Estimate)

Contract Completed: No

COMMENTS: The priority of this project was raised at the request of RPD.

RESULTS: An extensive compilation of plant/soil concentration ratios was presented and the appropriateness of using these as default values was evaluated. It was found that there were large gaps in the information, especially data for thorium and lead-210. The data were not adequate to categorize concentration values by soil types, in particular those found near mining-milling and tailing operations in Canada.

EVALUATION:

PUBLICATIONS: INFO 0230, "Review of Effect of Soil on Radionuclide Uptake by Plants".

REVIEW PANEL ACTIVITIES: Review Panel S3: The Panel attended the debriefing seminar and members received the final report for comment.

86.4.7 **Survey of Data on the Radionuclide Content of Fish

Category - 1 File Number: 34-14-1-9
Contractor - Beak Consultants Limited (Dr. D. Hart)
Mississauga, Ontario

It is proposed to survey and evaluate all available data on the radionuclide content of fish taken from waters in the vicinity of uranium mines and mills.

Much information exists concerning the radionuclide content of fish and the transfer of radionuclides into fish. However, as most of the data are presented in tabular form or in review articles it is difficult to judge the validity of the information when presented in these forms. There is a need to evaluate the information as originally presented so that a reliable and accurate database may be established.

The results of the project would be used in dose calculations, pathways analyses or derivations of release limits where accurate and reliable data for assessing the transfer of radionuclides to fish are required.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$20,000.00	$0.00	$20,000.00
Actual Spending:	$0.00	$25,265.00	$0.00	$25,265.00

Contract Completed: Yes

COMMENTS: Part of the deliverables for this study were diskettes containing the data. D-base III+ was used to organize the data base.

RESULTS: This study resulted in the compilation of a computerized database of uranium and thorium decay-series radionuclide concentrations in Canadian fish, including concentrations of U-total, Th-total, Th-230, Th-232, Th-228, Ra-226, Po-210 and Pb-210 in various fish tissues. The majority of the data pertain to Saskatchewan samples, with limited representation of Ontario, British Columbia and the Northwest Territories. Most of the radionuclide measurements are of U-total, Ra-226 and Pb-210. The survey identified the need for more data on thorium, thorium isotopes and polonium-210 in order to reliably estimate transfer coefficients for these radionuclides in the water(sediment)-fish-man pathway.

EVALUATION:

PUBLICATIONS: INFO 0231-1, "Survey of Data on the Radionuclide Content of Fish in Canada"; and INFO 0231-2, "Survey of Data on the Radionuclide Content of Fish in Canada - A Report Appendix".

REVIEW PANEL ACTIVITIES:

86.4.8 **Suspended Solids in Liquid Effluents: Literature Survey

Category - 1 File Number: 34-14-1-8
Contractor - Atlantic Nuclear Services (J.J. McGrath)
Fredericton, N.B.

It is proposed to conduct a survey of available literature to determine what investigations have been made concerning particulates and suspended solids in the liquid effluents of operating nuclear power reactors.

Particulates and suspended solids are an acknowledged portion of the liquid effluents at nuclear generating stations, but little is known about these materials or their environmental fate.

Information concerning the nature and environmental fate of solids and particulates in the liquid effluents of nuclear power stations would be of use to AECB staff in determining whether more specific guidelines are required in this area.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$0.00	$25,000.00
Actual Spending:	$0.00	$24,955.00	$0.00 (Estimate)	$24,955.00 (Estimate)

Contract Completed: No

COMMENTS: The scope was revised to include the survey of information on related utility and regulatory practices in other countries. Draft final report is being reviewed.

RESULTS: The preliminary results of the project indicate fairly clearly that the physico-chemical processes involved in suspended solid transport and deposition are not yet fully understood.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.4.9 Transfer of Radionuclides to Human Milk - Phase 2 Feasibility

Category - NEW File Number: 34-14-1-11

It is proposed to identify and test techniques for determining the concentrations of isotopes of uranium, thorium, radium and lead in human milk and to establish procedures for taking, preparing and storing the samples prior to analysis. In addition it is proposed to obtain a detailed plan for carrying out a field study using the chosen techniques.

This study is proposed because data on the role of human milk in radionuclide transfer are virtually non-existent. In order to obtain these data appropriate analytical and sampling procedures need to be established.

The results of this study would be used to determine the feasibility of conducting a full-scale sampling and analytical program to determine the concentration of selected radionuclides in human milk and the role of human milk in radionuclide transfer.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$0.00	$40,000.00

Contract Completed: No

COMMENTS: Contractor to be selected.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Appropriate members of the panel on Environmental Pathways were involved in the preparation of the work statement for this contract.

MISSION OBJECT 5 - WASTE MANAGEMENT

84.5.1 The Cost of Decommissioning Uranium Mill Tailings

Category - 1* File Number: 34-5-2-49
Contractor - IEC Beak Consultants Ltd. (Dr. W. Eedy)
Mississauga, Ontario

It is proposed to estimate the initial and on-going costs of decommissioning uranium mill tailings and the costs associated with maintaining any institutional controls that may be required.

This study is proposed because, even in the absence of a truly "walk-away" situation, tailings should be decommissioned in a mannner which will not constitute an unacceptable risk to future generations. To ensure that the risk does not increase following the completion of decommissioning, institutional controls may be necessary to avoid intrusion and to provide remedial action.

A knowledge of the costs of decommissioning and perpetual care is needed to determine how much money should be set aside and to evaluate the financial impact of regulatory requirements. The information is also necessary to be able to verify or question with authority claims made by the licensees regarding costs.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$27,000.00	$1,000.00	$0.00	$28,000.00
Actual Spending:	$28,068.64	$0.00	$0.00	$28,068.64

Contract Completed: Yes

COMMENTS:

RESULTS: Cost estimates for the decommissioning of a generic 40 ha above-ground site were in the range $2.5 to $3.75 million, depending on site remoteness. When costs were applied to tailings sites for which actual mining company estimates were known, the variance ranged from -1 to +39%. In most cases, the higher costs estimated by generic evaluation resulted from savings due to companies using internally available equipment or resources. This emphasizes the importance of careful planning. An all-inclusive environmental monitoring program was estimated to cost an average of $34,000 per year for the first five years, reducing to $11,000 or less thereafter. Site-specific variables will alter this cost.

EVALUATION: This report was judged to be adequate, but not excellent. The principal deficiencies identified were that tasks relating to discussions of institutional controls were not completed, and there is little information from international sources, though such information was requested. The reason for the problems is attributed, in large part, to the work statement which could have been more precise and which requested far more than could be delivered for the amount of money available. Regarding usefulness, it has been noted that the information would be useful for general considerations but not for site-specific cases, a point that was made by the contractor as well.

PUBLICATIONS: INFO 0198, "The Cost of Decommissioning Uranium Mill Tailings".

REVIEW PANEL ACTIVITIES:

84.5.2 Doses Resulting from Intrusion into Uranium Tailings Areas

Category - 1* File Number: 34-5-2-47
Contractor - W&W Radiological & Environmental Cons. Serv. Inc.
(M. Walsh)
Willowdale, Ontario

It is proposed to estimate the doses that could occur as a result of a range of scenarios involving humans coming into contact with decommissioned tailings at which institutional controls have lapsed.

This study is proposed in order to provide an improved, quantitative appreciation of the risks posed by uranium mill tailings.

The results of the study will assist the AECB to define, in a more precise manner, its regulatory position on tailings management.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$10,000.00	0.00	$0.00	$10,000.00
Actual Spending:	$9,826.25	$0.00	$0.00	$9,826.25

Contract Completed: Yes

COMMENTS:

RESULTS: The most likely intrusion scenarios would be those involving recreational activities, which could deliver annual doses as high as 10 mSv. Intrusion related to agricultural and habitational activities could result in even greater annual doses, up to several hundred mSv.

EVALUATION: Despite errors in data and the presence of typographical errors in the report, the final product is regarded as a good first attempt and has been judged as adequate.

PUBLICATIONS: INFO 0182, "Doses Resulting from Intrusion into Uranium Tailings Areas".

REVIEW PANEL ACTIVITIES:

84.5.4 Shallow Disposal of Radioactive Waste - Survey of Models

Category - 1* File Number: 34-5-2-39
Contractor - Geologic Testing Consultants Ltd.
(D.W. Lafleur, J.E. Campbell)
Ottawa, Ontario

A project is under way to survey and evaluate existing models which describe the release and migration of radionuclides from shallow disposal facilities.

At present it is not known if a model exists that is able to calculate dose to man resulting from the migration of radionuclides from shallow disposal facilities.

The information from this project will aid in the choice of model which can be used, initially, to describe a generic radioactive waste disposal facility.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$22,000.00	0.00	$0.00	$22,000.00
Actual Spending:	$22,383.02	$0.00	$0.00	$22,383.02

Contract Completed: Yes

COMMENTS:

RESULTS: The computer code PRESTO was recommended for use in subsequent phases of this overall program.

EVALUATION: The work was satisfactorily completed. This research forms part of a larger project for assessing the performance of potential shallow disposal facilities in Canada. It was a necessary stepping stone in a process of selecting a suitable program for installation on the AECB's own computer.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.5.5 Impact of Radiation on Containment in Waste Disposal

Category - 1* File Number: 34-5-2-56
Contractor - Spectrum Engineering Corp. Ltd (G. Mallory)
Willowdale, Ontario

A project is under way to assess the effects of radiation on all components of the deep geological disposal system which are likely to be affected by radiation.

This is being done through a study of available data, and emphasis being placed on the near-field components: the waste-form, canisters, buffer and backfill materials and the host rock. Following the assessment of the effects, the likely impact of radiation on the effectiveness of a deep disposal system will be examined.

It is anticipated that the results of this study will be used in developing guidelines and evaluating submissions to the Board, most particularly those addressing the design of the deep geological repository and its contents.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$31,000.00	$14,000.00	$0.00	$45,000.00
Actual Spending:	$30,500.00	$14,000.00	$0.00	$44,500.00

Contract Completed: Yes

COMMENTS:

RESULTS: The concept as currently envisaged has been documented and involves placing containers of wastes in mined vaults at approximately 1 km depth in plutons in the Canadian Shield. Each container will be placed in a separate vault, all will be packed around with buffer material (bentonite clay and sand, with additivies) and the rooms will be backfilled and sealed. The immediate surroundings of the containers (the buffer) will be subjected to radiation at dose rates initially reaching approximately 20 Sv h^{-1} for UF and about 150 Sv h^{-1} for FRW. Damage to minerals, except for certain sensitive ones such as calcite, appears to require absorbed doses in excess of 10^{10} Gy, and at the same time dose rates in excess of 10^{3} Gy h^{-1}. In consequence, there appears to be little danger of direct radiation damage occurring to the buffer. Potentially more serious is the micro and macrofracturing likely to develop due to stress changes and blasting effects associated with vault and shaft excavation. The effect on groundwater flow from the thermal gradient may be significant in the vicinity of the vault.

EVALUATION:

PUBLICATIONS: INFO 0216, "Impact of Radiation on Containment of Radioactive Waste in Deep Disposal Sites".

REVIEW PANEL ACTIVITIES:

84.5.6 Effects of Radiogenic Heat on Groundwater Flow

Category - 1* File Number: 34-5-2-51
Contractor - RE/SPEC Ltd. (Dr. H.Y. Tammemagi)
Calgary, Alberta

It is proposed to evaluate the effect on groundwater flow of heat generated by high-level radioactive waste in a deep geological disposal facility.

This work is proposed to determine if the heat generated by wastes in a deep geological facility could significantly affect the containment of the wastes by perturbing groundwater flow.

If radiogenic heat does substantially affect groundwater flow then further analyses may be warranted and additional effort may be required of the national program on deep geological disposal and in the writing of guidelines.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$40,000.00	0.00	$0.00	$40,000.00
Actual Spending:	$39,597.84	$0.00	$0.00	$39,597.84

Contract Completed: Yes

COMMENTS:

RESULTS: The effects of heat upon groundwater flow are manifold. For example, thermal stresses may induce fracturing or alter the apertures of existing fractures and, hence, change the rock mass permeability. However, the main effect is expected to be in the form of perturbations to the natural flow caused by induced convection, which could either increase or decrease the time for radionuclides to reach the biosphere. Perhaps one of the most important conclusions drawn from the work is that the approaches taken to assess the effects of heat are inadequate due to simplified assumptions such as the use of porous medium models to explain flow and perturbations of flow in fractured rocks. In order for meaningful results to be obtained more realistic approaches will be required.

EVALUATION: The study produced a good, comprehensive, summary reference on the subject, featuring illustrative and helpful case histories. However, the presentation on fracture flow could have been clearer, and a discussion on the conditions under which heat might lengthen or shorten groundwater travel time should have been included.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.5.8 Geological Conditions Relating to Oklo - A Review

Category - 1* File Number: 34-5-2-52
Contractor - Ontario Hydro (Dr. A. Jakubick)
Toronto, Ontario

It is proposed to fund a study to determine whether sufficient information exists to warrant a more in-depth evaluation of the conditions which affected radionuclide migration and retention during the natural nuclear reaction which took place at Oklo two billion years ago.

This study is proposed because if an in-depth study is feasible it should be conducted to determine the relevance of this event to the Canadian deep disposal program.

The results of this review will help in deciding whether a more detailed investigation is warranted.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$5,000.00	0.00	$0.00	$5,000.00
Actual Spending:	$5,000.00	$0.00	$0.00	$5,000.00

Contract Completed: Yes

COMMENTS:

RESULTS: The data from Oklo provide a site-specific description of the Oklo phenomenon, which is well known to people involved with nuclear waste disposal. However, in order to ascertain whether or not a similar phenomenon could be expected in Canadian geological environments being considered for nuclear waste disposal, a thorough, quantitative analysis of the geological processes and conditions, which obtained at Oklo, is required. The report illustrated that existing data from Oklo could not be utilized to make predictions regarding radionuclide migration within and through plutonic rocks on the Canadian Shield.

EVALUATION: This project was considered to be very successful in terms of the amount of work done, adherence to the scope, documentation, and fulfillment of the objective.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.5.9 An Evaluation of Information on Vertical Crustal Movements

Category - 1* File Number: 34-5-2-55
Contractor - Fracflow Consultants Inc. (Dr. J. Gale)
St. John's, Nfld.

It is proposed to continue to evaluate, through a survey of the literature, whether sufficient information is available to determine the effects that vertical crustal movements may have on subsurface rock and groundwater systems associated with a deep geological disposal facility.

As the earth's crust is uplifted it is suspected that new fractures may develop or old ones may re-open and, as a result, groundwater conditions may change. The result of this work will help assess what impact these effects may have on the ability of an underground system to adequately contain radioactive waste.

It is expected that the results of this study will augment the capabilities of AECB staff in the evaluation of the concept assessment phase of the deep disposal program.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$20,000.00	0.00	$0.00	$20,000.00
Actual Spending:	$19,934.00	$0.00	$0.00	$19,934.00

Contract Completed: Yes

COMMENTS:

RESULTS: In summary; 1) the literature is sufficient to define the range of the displacements that have taken place on discrete fractures, 2) the basic theory on glacial-isostatic movement is sufficiently well developed to enable one to define the horizontal and vertical (depth) extent of such movements along existing discontinuities, 3) sufficient laboratory data on fracture mechanics (properties) and the stress-fracture permeability relationships exist to approximate the impact that movements of the magnitude observed would have for different contractant and dilatant conditions on the permeability of discontinuities in fractured crystalline rocks, 4) existing three-dimensional numerical models provide an adequate tool with which to analyze the impact of vertical crustal movements on existing groundwater flow systems.

EVALUATION: This project is regarded as having been very well done and will be used in assessing information provided by AECL on the effects of vertical crustal movement on groundwater flow.

PUBLICATIONS: INFO 0185, "An Evaluation of Information on Vertical Crustal Movements Pertaining to Deep Disposal".

REVIEW PANEL ACTIVITIES:

84.5.11 Waste Management Implications of Concentrating Slimes

Category - 1* File Number: 34-5-2-50
Contractor - IEC Beak Consultants Ltd. (Dr. R. Nicholson)
Mississauga, Ontario

It is proposed to evaluate the physical and chemical behaviour of tailings which remain after the coarse fraction has been removed for use as backfill underground.

This work is proposed because the remaining tailings contain an enhanced proportion of slimes and most of the original radium, and are relatively impervious to water flow. Because of these properties there is a need to know what the short- and long-term implications are for tailings management.

The results of this study should enable the AECB to determine whether or not, as a result of concentrating the slimes, additional licensing conditions should be imposed, both for the operational and post-operational stages of mill tailings management. The results should also enable AECB staff to assess the claims made by licensees regarding the implementation of this practice.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$24,000.00	$3,000.00	$0.00	$27,000.00
Actual Spending:	$24,435.67	$2,984.36	$0.00	$27,420.03

Contract Completed: Yes

COMMENTS:

RESULTS: Slimes may be generally characterized as silt-sized particles (less than 200 mesh or 75 microns) with high water contents, relatively low permeability, low density and high compressibility relative to sand tailings. Plasticity indices range from low to high depending on clay content and mineralogy of the parent ore; Elliot Lake slimes are almost non-plastic, while Northern Saskatchewan slimes exhibit high plasticity. Radionuclides such as Ra-226 and Pb-210 are strongly associated with the fine particle fraction, and data from northern Saskatchewan slimes suggest that trace metals follow a similar pattern. In pyritic tailings (Elliot Lake) most of the metals are associated with pyrite and thus distributions are similar in coarse and fine tailings. Pyritic tailings generally exhibit low pH's and high concentrations of soluble metals, sulphate and radionuclides. However, due to the high water retention capacity of slimes, pyrite oxidation is inhibited and soluble contaminant concentrations may be lower than in coarse-grained tailings. Similarly radon gas exhalation from slimes may also be lower due to lower diffusion coefficients through the saturated tailings. Reclamation of slimes

by revegetation has been unsuccessful to date. Poor aeration of the root zone appears to be the major growth limiting factor, although under aerobic conditions, low pH and high concentrations of toxic element would inhibit growth.

EVALUATION: All but one of the tasks for this project were completed successfully, but the contractor failed to fulfill all of the objectives. Consequently, the work is regarded as only having provided some useful, background information. Due to the failure to fulfill all of the objectives completely, a second contract was needed, and is currently underway.

PUBLICATIONS: INFO 0195-1, "Waste Management Implications of Concentrating Slimes - Characteristics and Potential Problems".

REVIEW PANEL ACTIVITIES:

84.5.13 A Review of Subsurface Hydrogeologic Conditions

Category - 1* File Number: 34-5-2-57
Contractor - INTERA Technologies Ltd. (D.W. Lafleur)
Ottawa, Ontario

It is proposed to continue with the next phase of this project to review and interpet all available information on groundwater flow generated during studies relevant to the deep disposal of radioactive waste.

This study is a follow-up to the study entitled "A Review of Hydrogeology Research Techniques" and, together with that study, will provide information which will keep the AECB apprised of the most up-to-date information in the area of hydrogeology.

It is anticipated that this information will help AECB staff in evaluating the deep disposal program by providing independent information on groundwater conditions. It is also anticipated that the results would be useful in writing guidelines.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$43,000.00	$32,000.00	$0.00	$75,000.00
Actual Spending:	$42,958.00	$31,639.00	$0.00	$74,597.00

Contract Completed: Yes

COMMENTS:

RESULTS: A review of techniques and technology pertaining to the movement of ground water, solutes/radionuclides and heat through porous and fractured media was conducted. The theory describing each of these processes is presented in terms of their partial differential equations. The equations serve as the basis for the identification of processes. These parameters are discussed in detail with regard to their importance in controlling the overall transport processes. A hypothetical research program has been assembled for the purpose of illustrating the hydrogeologic methods and research techniques applicable to site characterization studies. Areas where the current state of the art is lacking have been identified and the necessary research has been recommended.

EVALUATION: The work was very well done and incorporated well presented data and evaluations with supporting arguments. The accomplishments are especially impressive when the vast quantities of data, dealt with by the contractor, are considered. The information obtained is expected to provide a good basis for evaluating hydrogeological data provided during the concept assessment phase, and actual site and regional investigation phases of the deep disposal of nuclear wastes in Canada.

PUBLICATIONS: INFO 0203 (1-4), "A Compilation of Subsurface Hydrogeologic Data - Volumes I-IV"; INFO 0221, "An Evaluation of Hydrogeologic Data of Crystalline Rock Systems"; and INFO 0222, "Mechanical Dispersion in Fractured Crystalline Rock Systems".

REVIEW PANEL ACTIVITIES: Review Panel S1: Work statement and draft and final reports were reviewed. Comments were addressed by the contractor. The Panel had no substantial impact other than to make relatively minor comments, which were addressed, and to state that work was well done.

84.5.14 Hydrogeological Factors to Be Addressed in Guidelines

Category - 1* File Number: 34-5-2-58
Contractor - INTERA Technologies Ltd. (D.W. Lafleur)
Ottawa, Ontario

It is proposed to continue this project on identifying those properties of groundwater and the conditions affecting groundwater flow which should be evaluated in determining the suitability of a site and region for the deep underground disposal of radioactive waste.

This study is intended to provide a perspective, independent of that held by AECB staff, which will ensure that AECB staff have not overlooked any relevant hydrogeological factors.

It is anticipated that this information will be used to modify existing guidelines or to write additional guidelines pertaining to the hydrogeological aspects of the deep disposal program.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$5,000.00	$30,000.00	$0.00	$35,000.00
Actual Spending:	$2,295.00	$30,124.00	$0.00	$32,419.00

Contract Completed: Yes

COMMENTS:

RESULTS: This report identifies the physical hydrogeologic factors that should be addressed for performance assessment of a radioactive waste disposal facility in plutonic rock. The hydrogeologic factors include theoretical methods, groundwater flow factors and solute transport parameters. Theoretical methods, including different deterministic and stochastic approaches for evaluating physical hydrogeologic conditions, are evaluated with respect to data requirements, applications and limitations. Preferred methods for measurement and determination of the identified groundwater flow factors and solute transport parameters are discussed. A recommended set of procedures for reliable hydrogeologic characterization of a plutonic rock mass at both regional and site scales is also presented.

EVALUATION: The study was well conducted and provides an appropriate technical basis for the development of regulatory guidelines. The information from this study will be used in writing detailed technical guidelines germane to hydrogeological conditions, and studies undertaken to determine those conditions, for the Canadian deep disposal program.

PUBLICATIONS: INFO 0223, "Hydrogeologic Factors to Be Addressed in Disposal Guidelines".

REVIEW PANEL ACTIVITIES: Review Panel S1: Work statement and draft and final reports were reviewed. Comments were addressed by the contractor.

84.5.15 **Shallow Ground Disposal - Calculation of Dose

Category - 1 File Number: 34-5-2-64
Contractor - INTERA Technologies Ltd. (D.W. Lafleur, J. Avis)
Ottawa, Ontario

It is proposed to proceed with a detailed feasibility study of adapting a model identified in a previous survey project (84.5.4) to calculate the doses that could result from various combinations of waste in different conditions of shallow ground disposal.

No suitably flexible program package was readily available with which to assess the performance of shallow disposal facilities.

This work will result, if feasible, in an implementation plan to adapt the model identified in project 84.5.4 to AECB requirements. Project 86.5.5 will carry out this implementation plan allowing AECB staff to assess license applications relating to the shallow disposal of radioactive waste. The model will also be used in determining what wastes might be suitable for disposal in shallow ground facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$22,000.00	$35,000.00	$0.00	$57,000.00
Actual Spending:	$0.00	$29,492.00	$0.00	$29,492.00

Contract Completed: Yes

COMMENTS:

RESULTS: The PRESTO-CPG model was evaluated in detail with respect to AECB requirements. Due to the lengthy computation time that would be required, it would not be feasible to run a probabilistic sampling version of PRESTO-CPG on the AECB's hp1000 minicomputer. A deterministic version would be feasible and would require approximately 20 person-months of software development to meet AECB requirements.

EVALUATION: Not yet initiated.

PUBLICATIONS: INFO 0229, "Shallow Ground Disposal - Calculation of Dose (Assessment of the PRESTO Model to Meet AECB Requirements)".

REVIEW PANEL ACTIVITIES: Review Panel S4: No activity as Panel only formed in late March 1987.

84.5.17 Ecological Dynamics of Uranium Mills Tailings

Category - 1* File Number: 34-5-2-41
Contractor - University of Toronto (M. Kalin)
Toronto, Ontario

It is proposed to fund the final phase of an on-going project on the way in which natural vegetation proceeds on abandoned tailings.

This study would focus on factors which affect radionuclide uptake and transfer in vegetation both within and beyond the tailings pile.

The results should be useful in evaluating claims made by licensees regarding biological pathways from uranium tailings piles.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$67,000.00	0.00	$0.00	$67,000.00
Actual Spending:	$66,661.50	$220.66	$0.00	$66,882.16

Contract Completed: Yes

COMMENTS: This was the final phase of a series of four related contracts. The expenditure on the final contract was $51,374. During the course of the contract, the researcher left the university to form her own company. A draft final report was received, but attempts to acquire a final version of the report proven unsuccessful and will not be pursued.

RESULTS: The long-term behaviour of the ecology on waste sites is affected by processes such as storms and fire, which underscores the complexity of evaluating radionuclide transfer in the long-term.

EVALUATION: Apparently useful data are presented but the lack of adequate discussion limits the value of the report in its present form.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.5.1 Estimation of Activity in Waste Packages - A Survey of Methods

Category - 1* File Number: 34-5-2-60
Contractor - Atlantic Nuclear Services Ltd.
(C.T. Scott, S.T. Friedman)
Fredericton, N.B.

This project will survey and evaluate methods currently used nationally and internationally in nuclear facilities to determine the inventories of radionuclides in waste packages destined either for storage or disposal.

This project has been proposed as part of an on-going effort to aid the AECB staff in their daily licensing activities by keeping their knowledge as current as possible.

The information gained by this project will be used by the AECB staff to assess present and proposed practices of waste package inventorying.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$5,000.00	$7,000.00	$0.00	$12,000.00
Actual Spending:	$2,303.94	$9,936.06	$0.00	$12,240.00

Contract Completed: Yes

COMMENTS:

RESULTS: The study provided a global review of current and proposed methods for estimating the radionuclide content of waste packages. It was found that current methods can be divided into two approaches. Both these approaches were discussed in detail. Proposals for new or improved methods were mentioned briefly but the level of effort for this project precluded any detailed discussion. A 22-page bibliography has been provided to assist in any further research.

EVALUATION: This contract was cost-effective and the work was performed satisfactorily. The results will be useful for AECB staff in the establishment of guidelines, the assessment of specific proposals, and in related compliance activities.

PUBLICATIONS: INFO 0208, "Estimation of Activity in Waste Packages - A Survey of Methods".

REVIEW PANEL ACTIVITIES:

85.5.3 Survey of Computer Codes for Flow and Contaminant Transport

Category - 1 File Number: 34-5-6-2
Contractor - Water and Earth Science Assoc.
(J. Gorrell, Dr. E. Frind)
Carp, Ontario

It is proposed to select and develop a two-dimensional, finite-element computer code for the calculation of groundwater flow and radionuclide transport through saturated and unsaturated porous media as found in mine tailings management areas or shallow surface waste storage and disposal sites.

Commercially available finite-element computer codes analyzing seepage through earthworks are primarily designed for stress analysis. Modification of these codes for flow and contaminant transport introduces difficulties. In addition, the cost of performing sensitivity analyses on transient models is prohibitive. Thus there is a need to review and evaluate existing models and select one for modification and use on the HP-1000 computer.

At the present time AECB staff are reviewing three licensing submissions which involve the modelling of radionuclide migration. The model selected and developed under this project would enable the AECB staff to perform their own independent calculations and thus be in a much better position to assess the approaches and results contained in the submissions. In addition the model which is selected and developed could be used as one of the components of the models being developed in a concurrent project, "Shallow Ground Disposal - Calculation of Dose."

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$5,000.00	$30,000.00	$0.00	$35,000.00
Actual Spending:	$6,100.00	$32,400.00	$0.00 (Estimate)	$38,500.00 (Estimate)

Contract Completed: No

COMMENTS: Some amendments to the final report are still outstanding.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.5.7 **Movement of Radionuclides between Water and Sediments

Category - 1 File Number: 34-14-1-7
Contractor - Beak Consultants Ltd. (Dr. W. Snodgrass)
Mississauga, Ontario

It is proposed to identify and elucidate the most apparent mechanisms of radionuclide sedimentation and remobilization in the Serpent River surface water system and incorporate them into an existing model of the Region. This would be a joint project with the National Uranium Tailings Program at a total cost of $80K over two years.

To date little, if any, emphasis has been placed on the role of sediments in radionuclide transport through surface water systems. There are two main reasons for this. First, the complex interactions and mechanisms involved are not fully understood, and second, the field data required for elucidating the complex mechanisms are sparse.

By incorporating the mechanisms of water-sediment-radionuclide interactions into an existing model of the Serpent River drainage system, would enable Board staff to evaluate the significance of the role of sediments in deriving release limits and in calculating doses to humans resulting from the management of uranium mills tailings.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$0.00	$60,000.00
Actual Spending:	$0.00	$73,372.94	$16,553.06 (Estimate)	$89,926.00 (Estimate)

Contract Completed: No

COMMENTS: Work in final stages.

RESULTS: At the time of this report, laboratory measurements of sorption characteristics, chemical fractionation of Ra-226 in sediments, mineralogical properties of sediments using nuclear emulsion technique, and desorption rate of Ra-226 from an intact sediment had been completed. These data were used to verify the computer model estimates of important processes responsible for transport of radionuclides from sediments to water. The final runs for verification and calibration of model coefficients and the report writing are in progress.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.5.8 **Verification and Validation for Waste Disposal Models

Category - 1 File Number: 34-5-6-3
Contractor - INTERA Technologies Ltd. (D.W. Lafleur, J. Avis)
Ottawa, Ontario

It is proposed to survey the latest developments in verification, validation and software quality assurance methods applied to modelling software. The survey would identify the best applicable methods for testing and assuring quality of nuclear waste disposal software modelling systems.

AECB staff will be required to assess licensee submissions concerning the predicted performance of existing and proposed nuclear waste disposal facilities. Some of these performance predictions will be generated by software modelling packages currently under development by industry and other government agencies. The validity of the modelling results is related directly to the effectiveness of the verification, validation and quality assurance methods used in model design and development.

The results of the survey will assist AECB staff in assessing the effectiveness of the verification, validation and quality assurance aspects of a particular model and hence the qualitative degree of confidence to be assigned to the model's predictions.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$0.00	$25,000.00

Contract Completed: No

COMMENTS: The original project "Verification, Validation, and QA for Waste Disposal Models" was divided into two separate projects: i) 85.5.8 Verification and Validation for Waste Disposal Models; and ii) 87.5.4 Software Quality Assurance for Waste Disposal Models.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S4: None, as Panel only formed in late March 1987.

85.5.9 **Optimization in the Decommissioning of Uranium Tailings

Category - 1 File Number: 34-5-7-0
Contractor - MacLaren Plansearch Inc. (A. Buchnea)
Toronto, Ontario

It is proposed to fund a project jointly with the National Uranium Tailings Programme. The project would survey the literature to determine optimization techniques which could be applied in the evaluation of decommissioning options for Canadian uranium mill tailings. For techniques which are identified to be so applicable, the project would also demonstrate precisely how each technique could be used in the evaluation of decommissioning options.

In the licensing process, the AECB requires optimization analyses to be performed, to ensure that exposures are as low as reasonably achievable (the ALARA principle). In relation to this process, the AECB requires information on techniques which may, in principle, be applied to the specific case of evaluating options for the decommissioning of uranium mill tailings.

The information obtained from the project would be used as input to the licensing process when evaluating licensee submissions relating to the decommissioning of uranium mill tailings.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00
Actual Spending:	$0.00	$30,000.00	$0.00	$30,000.00

Contract Completed: No

COMMENTS: The draft final report is in preparation.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.5.1 **Waste Management Implications of Concentrating Slimes - II

Category - 1 File Number: 34-5-2-50
Contractor - Beak Consultants Limited (Dr. R. Nicholson)
Mississauga, Ontario

It is proposed to compile and review information on the management of uranium and non-uranium tailings in order to prepare a report suggesting methods for overcoming the problems of concentrating slimes identified in the first phase of this study (84.5.11).

Current plans call for backfilling uranium mines with the coarse fraction of tailings, leaving a residue of fines, or slimes. However, certain chemical, geological and mechanical problems arise from concentrating the slimes. The AECB needs to be apprised of any proven, or even well-conceived but as yet non-implemented, techniques for dealing with these problems.

It is anticipated that the results of this work will provide the AECB with a compiled source of information which can be used in evaluating operating and decommissioning proposals by licensees.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$24,000.00	$25,000.00	$0.00	$49,000.00
Actual Spending:	$0.00	$15,000.00	$35,000.00 (Estimate)	$50,000.00 (Estimate)

Contract Completed: No

COMMENTS: No report has been received. The contractor did not meet the original contract deadline, thus the contract deadline was extended, but with no increase in funds.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.5.2 **State-of-Stress and Groundwater Flow

Category - 1 File Number: 34-5-2-65
Contractor - Fracflow Consultants Inc. (Dr. J. Gale)
St. John's, Nfld.

It is proposed to utilize existing boreholes at the Roblindale Quarry in order to monitor groundwater flow directions and rates in the underlying Precambrian granite.

This study is proposed in order for the AECB to acquire independent information on the flow of groundwater through fractures in plutonic rock. It is also being proposed to determine if the predominant flow direction is in any way related to the orientation of the ambient principal stresses at the quarry.

The results of this study would be used to evaluate information on groundwater flow which will be submitted to the AECB as part of the Concept Assessment phase of the Canadian Nuclear Fuel Waste Disposal Program.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$55,000.00	$0.00	$55,000.00
Actual Spending:	$0.00	$47,500.00	$7,010.00 (Estimate)	$54,510.00 (Estimate)

Contract Completed: No

COMMENTS: All field work and preliminary analysis of the data has been completed. However, before submitting the draft final report, the contractor needs to re-evaluate some of the drill cores.

RESULTS: Very preliminary results suggest that there may be a relationship between stress orientation and fracture permeability.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S1: Nothing has yet been submitted for review.

86.5.3 **Performance of Engineered Barriers for Low-Level Wastes

Category - 1 File Number: 34-5-2-62
Contractor - Geotechnical Resources Ltd. (A. Paré)
Calgary, Alberta

It is proposed that a literature review be conducted to synthesize and interpret the information available on the performance of engineered barriers used in the disposal of low level wastes.

At the present time, simple assumptions about the waste form and surrounding barriers are often used in modelling and safety assessment studies. However, the consequences of various release mechanisms and exposure pathways are likely to be sensitive to variations in the properties of the engineered barriers. Of particular interest is the transport of water and radionuclides through the barriers and how this changes with time as a result of degradation under shallow burial conditions in representative regions of Canada.

It is anticipated that the results of the literature review and synthesis will be of use to AECB staff in decisions relating to the long-term performance of barriers in waste storage facilities, nuclear facilities undergoing decommissioning, and waste disposal facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$35,000.00	$0.00	$35,000.00
Actual Spending:	$0.00	$28,672.00	$3,228.00 (Estimate)	$31,900.00 (Estimate)

Contract Completed: No

COMMENTS: The draft final report did not provide information on laboratory or field conditions or data resulting from laboratory experiments or field observations. This information must be included before the final report can be accepted.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.5.4 **Methodology for Estimating Probabilities of Intrusion

Category - 2 File Number: 34-5-2-63
Contractor - Beak Consultants Limited (Dr. W. Eedy)
Mississauga, Ontario

It is proposed that a generic methodology be developed for estimating the probabilities of intrusion scenarios for different types of waste management facilities. The methodology would take into account inter alia burial depth, location, current and projected land-use patterns and facility design.

Inadvertent human intrusion is an issue that is raised when considering nuclear fuel waste disposal, low-level waste disposal and uranium tailings management, yet there is no consensus on how it should be addressed by either regulators or licensees.

It is anticipated that the results of the study would be used in giving guidance to licensees in conducting safety and performance assessments and in applying regulatory criteria. The study when factored into the licensing process for waste management facilities would serve to clarify the need for, and length of time required for, institutional controls and various types of land-use restrictions.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$20,000.00	$0.00	$20,000.00
Actual Spending:	$0.00	$29,833.62	$0.00 (Estimate)	$29,833.62 (Estimate)

Contract Completed: No

COMMENTS: Draft final report being reviewed.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.5.5 Calculation of Dose from Shallow Ground Disposal

Category - 2

It is proposed to proceed with the implementation of a shallow ground disposal systems model built around a model identified in previous survey projects (84.5.4), but adapted to Canadian conditions and AECB requirements. The implementation plan to be followed, results from the preceding feasibility phase (84.5.15).

No suitably flexible program package appropriate for Canadian conditions was readily available with which to assess the performance of shallow disposal facilities.

This work will aid AECB staff in assessing licence applications relating to the shallow disposal of radioactive waste. The model will also be used in determining what wastes might be suitable for disposal in shallow ground facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$25,000.00	$65,000.00

Contract Completed: N.A.

COMMENTS: The decision of whether or not to proceed will depend on the evaluation of 84.5.15.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S4

86.5.7 **Erosion of Surface and Near-Surface Disposal Facilities

Category - 1 File Number: 34-5-2-61
Contractor - MacLaren Plansearch Inc. (A. Ashamalla)
Toronto, Ontario

It is proposed to evaluate available information on the erosion of naturally occurring, unconsolidated sediments in order to estimate the length of time that surficial and near-surface disposal facilities are likely to resist erosion and prevent the release of unacceptable concentrations of radioactive materials.

This study is proposed because, to date, certain licensees consider only uniform sheet erosion when estimating the length of time that a disposal facility will provide adequate containment of radioactive waste. However, because of the rapidity of some erosional processes relative to sheet erosion, such as gully formation, it is suspected that containment may not be maintained for as long a period of time as currently claimed by the licensees.

The results of this program will be used determining the acceptability of the approach currently adopted by the licensees regarding the erosion of surface and near-surface waste disposal facilities. The results may also indicate whether guidelines specifically addressing this phenomenon should be written.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$20,000.00	$50,000.00
Actual Spending:	$0.00	$16,200.00	$1,800.00 (Estimate)	$18,000.00 (Estimate)

Contract Completed: No

COMMENTS: Relatively little data exist, but those that do exist were not furnished in the draft final report. Thus a second draft has been requested to ensure that data, which were uncovered during the literature search, are included.

RESULTS: The study shows that far more information is required before a meaningful assessment of erosion on surface and near-surface facilities can be undertaken.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.5.8 **Plotting for a Groundwater Flow/Contaminant Transport Model

Category - NEW File Number: 34-5-6-4
Contractor - Cube Systems Consulting Services Inc.
(Dr. M-C Au, S. Conley)
Ottawa, Ontario

It is proposed to initiate a two-phase project involving plotting post-processing, tailored to AECB requirements, for the groundwater flow and contaminant transport model FEMWATER/FEMWASTE. This project would be dependent on the outcome of project 85.5.3, "Survey of Computer Codes for Flow and Contaminant Transport". Phase I would review the AECB requirements, evaluate the various solutions available and recommend a particular approach. Phase II would implement, in response to the AECB requirements, any software solutions recommended in Phase I. (Note that if Phase I simply recommended the purchase of plotting hardware compatible with existing FEMWATER/FEMWASTE plotting routines then Phase II would not be required.)

The existing plotting routines of FEMWATER/FEMWASTE are designed to interface with calcomp plotters and are apparently not compatible with the AECB's Hewlett-Packard plotters. Also, the existing FEMWATER/FEMWASTE plotting software may not be effective in representing the transport of the radioactive waste inventory for the Canadian site configurations to be assessed. Plotting of results is essential to enable AECB staff to effectively visualize and interpret the complex performance characteristics of a radioactive waste disposal facility.

The results of this project would improve the effectiveness with which AECB staff could use FEMWATER/FEMWASTE to assess licensees' performance predictions for existing and proposed waste disposal facilities.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$9,000.00	$9,000.00	$18,000.00
Actual Spending:	$0.00	$9,000.00	$9,000.00 (Estimate)	$18,000.00 (Estimate)

Contract Completed: No

COMMENTS: Due to the urgent need for this facility, AECB staff specified precisely the plotting requirements thus eliminating Phase I, allowing the project to proceed directly to Phase II.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.5.9 **Sensitivity Study of the Concept of Deep Geologic Disposal

Category - NEW
Contractor - Beak Consultants Limited (D. Lush)
Mississauga, Ontario

File Number: 34-5-2-66

A project is proposed to determine the most significant factors affecting the risk from the deep geologic disposal of nuclear fuel waste, based on a sensitivity analysis of the risk calculation. The analysis should begin with the sensitivity of the final result to the variation in major calculation segments. The sensitivity of the important major segments and their respective sub-segments to input variables will be investigated. This is a "top down" approach, with each analysis progressively more detailed.

Current assessments of deep geological disposal are carried out using a large, complex computer model, SYVAC, to do a Monte Carlo analysis of the post-closure risk to the public. The AECB needs to take a broad look at the major sub-systems and processes to determine the overall effects they may have on the risk predictions. Also, with several hundred input parameters in a model, it is necessary but very difficult to identify which parameters are important (or even limiting) to the risk calculation.

The results of this research will allow Board staff: a) to direct their evaluation of the concept assessment to the most important areas (sub-systems, processes, pathways, parameters and correlations); b) to set the criteria to judge the adequacy of the information, understanding, models and database in a particular area; and c) to evaluate the significance of the various components in the risk calculation done using SYVAC.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$9,000.00	$21,000.00	$30,000.00
Actual Spending:	$0.00	$9,000.00	$20,647.93 (Estimate)	$29,647.93 (Estimate)

Contract Completed: No

COMMENTS: The draft final report is in preparation.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

MISSION OBJECT 6 - NON FUEL CYCLE APPLICATIONS

84.6.1 The Radiological Impact of Waste Disposal

Category - 1* File Number: 34-5-2-48
Contractor - IEC Beak Consultants Ltd. (Mr. P. McKee)
Mississauga, Ontario

It is proposed to estimate the dose to the critical group in an intermediate size Canadian city in which small amounts of radioisotopes are released by disposal into sewers and landfills, and by incineration.

The collective and individual doses are being estimated to determine the appropriateness of current radioisotope disposal practices. The methods used to obtain the dose estimates are to be demonstrated and explained in a manner that will allow their use at other sites.

The knowledge of the collective and individual doses will aid in ensuring that current AECB regulations concerning the disposal of radioisotopes are appropriate.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$55,000.00	0.00	$0.00	$55,000.00
Actual Spending:	$69,152.06	$0.00	$0.00	$69,152.06

Contract Completed: Yes

COMMENTS: During the course of the study, several important new tasks were identified which resulted in significant revisions to the original scope and a commensurate increase in cost.

RESULTS: The results of the study show that within the occupational critical group the maximum dose calculated was 1.4×10^{-6} Sv/a. It was also calculated that the dose to a typical member of the critical group living in the study area would be in the order of 3×10^{-7} Sv/a. Both of these doses are significantly lower than the AECB's regulatory limit of 5×10^{-3} Sv/a for a member of the public. The project also described the methods of calculation in such a manner that similar calculations can be performed to determine the radiological impact of radioisotope waste disposal in other cities. A manual showing how to use the model and how to implement the models onto a computer spreadsheet was also produced.

EVALUATION: The work was satisfactorily completed and achieved the stated objectives. The contractor exhibited very good initiative and originality. The results of this work have been used in preparing AECB regulatory documents. They have also been used to help explain the impact of low-level radioactive waste disposal practices to the public.

PUBLICATIONS: INFO 0166/Rev-1, "Determination of the Radiological Impact of Radioisotope Waste Disposal".

REVIEW PANEL ACTIVITIES:

84.6.4 Development of a Canadian Gamma Radiography Training Manual

Category - 1* File Number: 34-10-3-0
Contractor - Friesen, Kaye & Associates (Mr. P. McBrien)
Nepean, Ontario

It is proposed to develop a training manual for prospective Canadian qualified operators on the procedures of working safely with gamma radiography equipment.

This work is proposed because industrial radiography cameras contain radioactive sources which may pose potential health hazards, and because operators of these cameras are required by AEC Regulations to pass an examination covering the following subjects: a) safety procedures; b) radiation protection principles; c) emergency procedures; d) knowledge of regulations.

It is anticipated that the manual will be used as a reference document by workers in their preparation for the certification examination to become AECB qualified operators.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$22,000.00	0.00	$0.00	$22,000.00
Actual Spending:	$21,235.53	$0.00	$0.00	$21,235.53

Contract Completed: Yes

COMMENTS: This project was completed satisfactorily.

RESULTS: This project has developed a training manual of safe working practices with gamma radiography equipment for prospective Canadian qualified gamma camera operators and it is to be used as a reference manual during their preparation for the certification examination to become AECB qualified operators. After making significant revisions to technical content and grammatical structure in the draft report, the contractor finally produced a manual which was satisfactory. The manual will be available in both official languages.

EVALUATION: The contractor required substantial supervision and review of his work in order to produce an acceptable training manual as specified in the contract. In the end, sufficient value for money was obtained from this project. This training manual, consisting of safe working practices with gamma radiography equipment, will be used as a reference manual by prospective Canadian qualified gamma camera operators during their preparation for certification examination to become AECB qualified operators.

PUBLICATIONS: Translation of the manual is underway, with a view to publishing it in bilingual format.

REVIEW PANEL ACTIVITIES:

84.6.8 Neutron Dosimetry for Oil-Well Logging Operations

Category - 1* File Number: 34-7-2-40
Contractor - Atomic Energy of Canada Limited (Dr. W.G. Cross)
Chalk River, Ontario

It is proposed to provide funding for this ongoing project to irradiate personal neutron dosimeters that incorporate both NTA film and CR-39, using the neutron fields encountered in oil-well logging operations, and to compare and evaluate the response of the two detector materials.

This work is proposed because of the difficulty of interpreting quantitatively readings from the NTA detectors at low exposure levels.

It is anticipated that the results of this research will be used, in conjunction with other information, to make decisions on licensees' requests for modifying their dosimetry practices (e.g., subscription to a neutron dosimetry service).

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$2,000.00	$6,000.00	$0.00	$8,000.00
Actual Spending:	$5,090.00	$4,892.00	$0.00	$9,982.00

Contract Completed: Yes

COMMENTS:

RESULTS: Neutron doses recorded by NTA emulsion dosimeters and CR-39 damage track dosimeters, for a small selected group of workers in the oil-well logging industry, have been compared over a one-year period. The same individuals wore NTA dosimeters for the normal one-month periods and CR-39 dosimeters for various periods from a month to a year. The results show that these workers often receive monthly dose equivalents between 30 μSv (as determined by CR-39 detectors) and the practical lower level of detectability (200 μSv) of the NTA dosimeters. However only 17% of the measured CR-39 dose equivalents totalled more than 1 mSv for the year, the maximum being 1.54 mSv. These dose equivalents are small compared with those received by many radiation workers in other industries.

EVALUATION: The contractor successfully completed the tasks set out in the work statement. Both the Evaluator and Scientific Authority indicate that the results have already proven useful, in that the experiment has revealed that the CR-39 detector is more sensitive to low energy neutrons than the

currently-used NTA film. This result has confirmed the decision of the BRMD to change its dosimetry system to one based on the more sensitive CR-39 detector. Therefore, the AECB should receive more accurate exposure information. Good value for the money expended has been obtained from this project.

PUBLICATIONS: INFO 0189, "Neutron Dosimetry for Oil-Well Logging Operations: An Intercomparison of NTA and CR-39 Dosimeters".

REVIEW PANEL ACTIVITIES:

84.6.10 Mechanical Testing of Capsules Used in Radiography Cameras

Category - 1*
Contractor - Alberta Research Council
Edmonton, Alberta

It is proposed to perform mechanical tests on capsules used in pneumatic radiography cameras.

Several sealed sources (capsules) used in pneumatic radiography cameras were recently found to have developed leaks. Because of the potentially hazardous situation that could arise as a result of a leaking capsule, it is essential that the cause of the leaks be determined.

The results of this project will be used to modify, as necessary, AECB design criteria for either the capsules or the cameras.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$76,000.00	0.00	$0.00	$76,000.00
Actual Spending:	$75,973.00	$0.00	$0.00	$75,973.00

Contract Completed: Yes

COMMENTS: The Alberta Research Council did much of development of the test equipment on their own initiative.

RESULTS: C-182 capsules were tested as proposed. It was found that under typical field conditions the capsules can become significantly deformed. The extent of the deformation is generally related to the number of cycles that the capsules undergo. Deformation occurs on the side of the capsules entering the camera first and is related only to the pneumatic operating mode of the camera. The only leak observed in this series of tests occurred at the weld end of the capsule when the weld end was oriented to enter the camera last. As a result of this contract, AECL is now redesigning the C-182 capsule and having the Alberta Research Council perform the tests carried out for the project on the new designs.

EVALUATION: This work was cost-effective and was performed very satisfactorily. Based primarily upon these results, the C-182 capsule was banned from use. The results also provided the basis for designing a new capsule. This report will be of general value to the AECB for evaluating or setting standards for such capsules.

PUBLICATIONS: INFO 0183, "Testing of Capsules Used in Radiography Cameras".

REVIEW PANEL ACTIVITIES:

85.6.1 To Develop a New Personal Neutron Dosimeter - Phase III

Category - 1* File Number: 34-7-2-34
Contractor - Atomic Energy of Canada Limited (Dr. H. Ing)
Chalk River, Ontario

It is proposed to provide funding for an ongoing project to study and assess the bubble-damage polymer detector for neutron radiation. Funding for this project began in FY 83/84 and is anticipated to continue to the end of FY 86/87. The work to be funded in each of FY 85/86 and FY 86/87 will depend upon the findings of the previous year's research. This project is also receiving financial support from AECL (the contractor).

This work was initiated because no single existing neutron dosimeter is considered to be acceptable for monitoring neutron radiation in a variety of different environments where neutron radiation can occur (e.g., particle accelerators, reactors, etc.). The detector in this work shows promise because it is simple to use, compact, direct reading, very sensitive to neutron radiation, insensitive to gamma radiation and probably capable of detecting neutron radiation in the keV energy range and lower.

It is anticipated that this work will stimulate the development of a personal neutron dosimeter for radiation protection purposes that is superior to currently-used personal dosimeters.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$149,000.00	0.00	$0.00	$149,000.00
Actual Spending:	$149,000.00	$0.00	$0.00	$149,000.00

Contract Completed: Yes

COMMENTS:

RESULTS: The results of the contract are proprietary.

EVALUATION: The evaluation for this project will be undertaken after the conclusion of Phase IV.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.6.3 Comprehensive Evaluation of the Berthold LB1200 Survey Meter

Category - 1* File Number: 34-7-2-56
Contractor - Monserco Limited (Mr. M.W. Davis)
Mississauga, Ontario

It is proposed to provide funds for the ongoing comprehensive evaluation of the performance characteristics of the Berthold LB1200 survey meter that takes into account the influence of ambient environmental conditions found in the field.

Radiation survey meters used in on-site inspections of licensees' facilities are frequently subjected to harsh environmental conditions. The influence of ambient temperature, humidity, r.f. fields, and other environmental parameters must be known quantitatively to convert accurately the meter reading to an exposure level. The LB1200 is the principal field survey meter used by AECB inspectors to assess compliance of licensees' operations with AEC regulations/licence conditions. Considering the legal implications of the assessments, the LB1200 should be subjected to a thorough, documented, comprehensive, and independent evaluation.

It is anticipated that the results of this study will provide AECB inspectors with a detailed understanding of the capabilities and limitations of the LB1200 when used in conditions encountered in the field.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$17,000.00	$1,000.00	$0.00	$18,000.00
Actual Spending:	$16,645.41	$1,367.59	$0.00	$18,013.00

Contract Completed: Yes

COMMENTS:

RESULTS: The performances of the two Berthold LB1200 survey meters were evaluated for a range of beta and photon radiation energies, encompassing the energies of most radioisotopes commonly used in Canada. The survey meters performed acceptably under most of the environmental conditions tested, with the exception of radiofrequency interference and electrostatic charge.

The X-ray/gamma energy response of the two meters, in the range of 0.059 to 1.33 MeV, was found to be typical of Geiger tubes. The efficiency (ratio of the meter reading to the true exposure rate in air) was 2 at 59 keV, increased to a maximum value of 3 at 85 keV, and dropped to a value of 1.2 at 200 keV. When a narrow beam of x-ray/gamma radiation was focussed onto only part of the Geiger tube, the true exposure rate in the beam could be calculated within 20% by correcting the meter reading for linearity, efficiency and fraction of tube exposed. Beta particles with energies from 0.158 to 2.27 MeV were measured using the thin end-window Geiger. The efficiency for beta particles from C14 was approximately 10 times lower than for beta particles from Sr90.

There were no observable effects on the analogue meter response of the two LB1200s from 1) temperature variations in the range of -30 to +30 degrees C; 2) the relative orientation of the survey meters in the gravitational and magnetic fields of the earth; and 3) relative humidity variations in the range 16% to 94%. Radiofrequency radiation in the range 30 Hz to 1 GHz was directed at all surfaces of the two survey meters. One meter exhibited an elevated count rate when rf interference in the range 30 to 1000 Hz was incident upon the bottom and side of the meter. When electrostatic potentials as low as 0.8 kV were put onto the plastic meter face, both meters exhibited pronounced impairment of meter needle movement.

During the operational battery test the survey meters were powered for 39 and 44 hours of continuous operation before the battery charge was depleted. The analogue meter response to the constant radiation source was unaffected by dropping battery voltage until the last few minutes of the test.

EVALUATION: The contractor successfully completed the tasks set out in the work statement. The final report provides AECB inspectors with a detailed understanding of the capabilities and limitations of the LB1200 when used in conditions encountered in the field.

PUBLICATIONS: INFO 0196, "Comprehensive Evaluation of the Berthold LB1200 Survey Meter".

REVIEW PANEL ACTIVITIES:

85.6.4 Neutron Quality Factor

Category - 1* File Number: 34-7-2-57
Contractor - Atomic Energy of Canada Limited
(Dr. J.R. Johnson, Dr. D.K. Meyers)
Chalk River, Ontario

It is proposed to investigate, by means of a critical review of the literature, the scientific basis for the neutron quality factor.

This study is proposed because at the 1985 meeting in Paris of the ICRP, the Commission recommended an increase in the neutron quality factor by a factor of 2. The detailed rationale for the recommendation was not given. The proposed doubling of the neutron quality factor will result in doubling of the dose equivalent (sievert) received from a given absorption of neutron energy per unit mass of tissue (gray). Therefore, if the ICRP recommendation is accepted by Canada, permitted neutron exposures will be divided by a factor of 2, possibly necessitating changes to current or future operating practices of AECB licensees. Therefore the AECB should review the physical and biological basis for the neutron quality factor to make an informed decision on this matter.

It is anticipated that the findings of this project will be essential in deciding whether Canada should follow the ICRP recommendation to increase the quality factor for neutrons by a factor of 2.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$15,000.00	0.00	$0.00	$15,000.00
Actual Spending:	$15,000.00	$0.00	$0.00	$15,000.00

Contract Completed: Yes

COMMENTS:

RESULTS: The report reviewed the available published information on the relative biological effectiveness (RBE) of neutrons and on the physical basis for the neutron quality factor for use in personnel dosimetry programs. It was concluded that some, but by no means all, of the RBE data supported an increased quality factor, but the relevance of this data to the quality factor for use in radiation protection is not clear for two reasons. Firstly, the biological endpoints are not all directly extrapolatable to late stochastic effects in humans, and secondly, the current conservative selection of a quality factor for neutrons, and the conservative practice of equating whole body dose to the maximum dose equivalent, leads to a factor of about 10 in conservatism in the assignment of neutron dose equivalents. The overall conclusion of the review was that there is no compelling reason to increase the quality factor for neutrons at least until the ICRP has completed its further comprehensive review of the subject.

EVALUATION: The contractor successfully completed the tasks set out in the work statement. The information compiled in the report provided convincing evidence that the quality factor for neutrons should not be increased by a factor of two, despite the earlier ICRP recommendation. The results of this study are of value to the AECB and support the continued use of a quality factor of 10 for fast neutrons as is proposed in the General Amendments to AEC Regulations.

PUBLICATIONS: INFO 0186, "A Review of the Scientific Basis for the Quality Factor for Neutrons".

REVIEW PANEL ACTIVITIES:

86.6.1 **To Develop a New Personal Neutron Dosimeter - Phase IV

Category - 1 File Number: 34-7-2-34
Contractor - Atomic Energy of Canada Limited (Dr. H. Ing)
Chalk River, Ontario

It is proposed to provide funding for an ongoing project to develop and assess the bubble-damage polymer detector for neutron radiation. Funding for this project began in FY 83/84 and is anticipated to continue to the end of FY 86/87. The work to be funded in each of FY 85/86 and FY 86/87 will depend upon the findings of the previous year's research. This project is also receiving financial support from AECL (the contractor).

This work was initiated because no single existing neutron dosimeter is considered to be acceptable for monitoring neutron radiation in a variety of different environments where neutron radiation can occur (e.g., particle accelerators, reactors, etc.). The detector in this work shows promise because it is simple to use, compact, direct reading, very sensitive to neutron radiation, insensitive to gamma radiation and probably capable of detecting neutron radiation in the keV energy range and lower.

It is anticipated that this work will stimulate the development of a personal neutron dosimeter for radiation protection purposes that is superior to currently-used personal dosimeters.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$149,000.00	$50,000.00	$0.00	$199,000.00
Actual Spending:	$149,000.00	$50,000.00	$0.00	$199,000.00

Contract Completed: No

COMMENTS:

RESULTS: The results are proprietary.

EVALUATION: The Post Project Evaluation is to be undertaken for the entire project (all four phases).

PUBLICATIONS: The AECB reports are proprietary. However, there have been seven publications in the open literature and 18 presentations based on results of this research.

REVIEW PANEL ACTIVITIES:

86.6.2 **Doses from Portable Gauges

Category - 1 File Number: 34-7-2-64
Contractor - Atomic Energy of Canada Limited (Mr. S. Linauskas)
Chalk River, Ontario

It is proposed to initiate a study to determine the doses received by operators of portable moisture-density gauges under various working conditions.

This study is proposed because the AECB has approximately 450 licensees for the use of portable moisture-density gauges. Currently, operators are not required to wear TLDs because the doses are normally low. However, depending upon the amount of use, the operator's procedures and the number of times the portable gauge has to be cleaned, the accumulated doses for individuals might become significant.

It is anticipated that the results of this study will provide information to the AECB to determine whether present operating procedures require changes and whether it is necessary for operators of portable gauges to wear TLDs.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00
Actual Spending:	$0.00	$29,550.13	$19,349.87 (Estimate)	$48,900.00 (Estimate)

Contract Completed: No

COMMENTS: Since significant extra work was authorized (by contract amendment) after the maintenance procedures were found to be associated with the highest neutron doses, the actual expenditures exceeded the originally estimated costs.

RESULTS: Dose measurements have been carried out on portable gauges used by a number of licensees in the western and central regions of Canada. It was found that significant neutron doses were encountered during the maintenance of the portable gauges. Dose measurements will be performed in FY 87/88 on portable gauges used by licensees in the eastern and Atlantic regions.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.6.3 **Laboratory System for Alpha Particle Spectroscopy

Category - 1 File Number: 34-7-2-62
Contractor - Monenco Analytical Laboratories
(Dr. N.W. Chiu, Dr. J.R. Dean)
Calgary, Alberta

It is proposed to develop an automated laboratory-based system for alpha particle spectroscopy that will be fully compatible with existing AECB laboratory equipment (including a Tennelec alpha detector, Tracor Northern Model 1706 pulse height analyzer, Canberra Series 85 multichannel analyzer (MCA), Nucleus alpha spectrometer, and other electronics). A sample changer and system controller will have to be designed, built and assembled.

This project is proposed because currently the AECB laboratory uses a single alpha detector and vacuum chamber for measurement of radium-226. The procedure involves the manual collecting and printing of the data, then the changing of the sample at the end of each measurement. Two to five samples can be processed per day. An automated system for sample changing and data collection would increase the number of samples the laboratory could handle by a factor of five, decrease possible operator error, and improve reproducibility. In addition, more effective use of the Canberra MCA would be possible.

It is anticipated that the system developed from this project will increase the capability of the laboratory to analyze samples for alpha-emitting radioisotopes.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$0.00	$40,000.00
Actual Spending:	$0.00	$43,170.25	$0.00	$43,170.25

Contract Completed: Yes

COMMENTS:

RESULTS: An automated alpha particle spectroscopy system has been designed and fabricated. It consists of two major components, the automatic sample changer and the controller/data acquisition unit. It is capable of unattended analysis of ten samples for up to 65,000 seconds per sample.

EVALUATION: Post Project Evaluation is underway.

PUBLICATIONS: INFO 0233, "Laboratory System for Alpha Particle Spectroscopy".

REVIEW PANEL ACTIVITIES:

86.6.4 Radiation Doses to Technologists from Radiotherapy Treatment Procedures

Category - 1

It is proposed to measure and compare the radiation doses received by radiotherapy technologists during the performance of their duties at three different treatment machines at the Allan Blair Memorial Clinic, Saskatchewan Cancer Institute, Regina, Saskatchewan. The three types of treatment machines are: cobalt-60 teletherapy unit, high energy linear accelerator (20 MeV), and low energy linear accelerator (4 MeV). Typical exposure values will be derived on a per-treatment basis for the more common treatment types, as well as on a weekly basis for each of the treatment machines included in this study.

This work is proposed because, in order to reduce the radiation exposure received by technologists in a radiotherapy department, it is necessary to identify the significant sources of exposure and their relative magnitudes. Also, the radiation exposures attributed to technologists may vary from machine to machine implying that there may be significant differences in exposure at the various machines. This study will measure the variations in exposures from machine to machine.

It is expected that the proposed research will provide information on the relative exposure received by technologists working on the different types of therapy machines. From this information, the AECB may be able to infer the mechanism by which the technologists receive the major part of their personal exposures. This information is essential in order to effect changes aimed at reducing personal radiation exposures, including the re-assignment of pregnant technologists to those duties where exposure is minimized as well as to develop new patient set-up techniques and protocols aimed at reducing the radiation exposure to the technologists.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$10,000.00	$0.00	$10,000.00

Contract Completed: N.A.

COMMENTS: The project in its proposed form was withdrawn at the request of the originator (Allan Blair Memorial Clinic) owing to their later decision to dispose of the cobalt-60 therapy machine. It was maintained as an active project, in an altered form, by Radioisotopes and Transportation Division. The project did not commence in FY 86/87 and was placed in a deferred category for FY 87/88.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.6.5 **Development of An Automated Method for Determination of Thorium in Soil Samples

Category - 1 File Number: 34-7-2-22
Contractor - Becquerel Laboratories Inc.
(Ms. J.E. Stuart, Dr. R. Robertson)
Mississauga, Ontario

It is proposed to develop an automated method, and the corresponding apparatus, for measuring the thorium content of soil samples. Such method and apparatus would complement the automated AECB laboratory equipment used for measuring thorium in liquids and aerosols.

In 1984, under another research contract, a method was developed for automating the determination of thorium in liquids and aerosols. The specialized equipment of the Board's laboratory was modified accordingly, and has performed routine thorium measurements satisfactorily since then. The report produced by the contractor mentioned that the apparatus could also be modified for automatic determination of thorium in soil samples. The number of soil samples to be analyzed can reach 200 samples in a year, and one sample, using manual techniques, can take about eight hours to analyze.

It is anticipated that the full automation of the AECB laboratory's thorium measurement apparatus will significantly reduce the time required to do thorium analyses and will free the staff for non-routine tasks. Automated measurement systems are also generally more reliable than those involving human intervention. (This project was first proposed as 86.8.14.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$10,000.00	$0.00	$10,000.00
Actual Spending:	$0.00	$9,875.00	$0.00	$9,875.00

Contract Completed: Yes

COMMENTS:

RESULTS: A methodology was further developed for determining trace thorium levels in a variety of sample types. Thorium in filtered water samples is concentrated by ferric hydroxide precipitation followed by dissolution and co-precipitation with lanthanum fluoride. Aerosols (on glass fibre, on cellulose ester, or on teflon filters) and solid soil and sediment samples are acid digested. Subsequently, thorium is concentrated by lanthanum fluoride co-precipitation. Chemical separation and measurement is then done on a Technicon AAII-C autoanalyzer, using solvent extraction into thenoyltrifluoroacetone in kerosene followed by back extraction into 2 N HNO_3, and colourometric measurement of the thorium arsenazo III complex. Chemical yields are determined by the addition of thorium-234 tracer using gamma-ray

spectrometry. The sensitivities of the methods for water, aerosol and solid samples are approximately 1.0 microgram/litre, 0.5 microgram/gram and 1.0 microgram/gram respectively. At thorium levels about ten times the detection limit, accuracy is estimated to be ±10% for liquids and aerosols and ±15% for solid samples. Precision is ±5% for all samples.

EVALUATION: The contractor successfully completed the tasks set out in the work statement. The technique developed during this project is currently being used in the AECB laboratory. The result of this work is permitting laboratory staff to turn more of their attention to the performance of non-routine tasks.

PUBLICATIONS: INFO 0211, "Development of an Automated Method for Determination of Thorium in Soil Samples and Aerosols".

REVIEW PANEL ACTIVITIES:

86.6.6 **Evaluation of Methods to Leak Test Sealed Radiation Sources

Category - NEW File Number: 34-7-2-69
Contractor - Atlantic Nuclear Services Ltd.
(Dr. C.K. Scott, Mr. N.D. Arbeau)
Fredericton, N.B.

It is proposed to produce a technical reference document, for use by Compliance Services and Laboratories Division (CSLD) inspectors of the Atomic Energy Control Board (AECB), that identifies suitable techniques for analyzing wipes used to leak test radioactive sources. The document will also describe a technique to test the reliability of procedures used to detect specified radioisotopes on wipes.

This project is proposed because CSLD inspectors routinely monitor a licensee's compliance with the licence condition requiring that leak tests be made on sealed sources. In the future, the inspectors will be more deliberate in determining not only that the tests have been done but that they have been done properly. The intention is that the results of the analysis of the wipe sample will be considered valid only if the licensee (or a commercial or government laboratory used by the licensee) has a documented procedure that stands up to CSLD evaluation (which will involve an assessment of the written procedure and possibly a test using doped wipes). In order to be effective and consistent in carrying out this responsibility, CSLD inspectors require a technical reference document of the type described above.

It is anticipated that the document produced by this project will be used by CSLD inspectors to monitor AECB licensees' compliance with the licence condition for leak testing of sealed radioactive sources. The document will also be used to provide guidance to Canadian industry on suitable analysis techniques for wipes.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00
Actual Spending:	$0.00	$18,360.40	$1,000.00 (Estimate)	$19,360.40 (Estimate)

Contract Completed: No

COMMENTS: The methods for the leak testing of sealed radiation sources were reviewed. One hundred and thirty-one equipment vendors were surveyed to identify commercially available leak test instruments. The equipment is summarized in tabular form by radiation type and detector type for easy reference. The radiation characteristics of the licensed sources were reviewed and summarized in a format that can be used to select the most suitable detection method. A test kit was proposed for use by inspectors when verifying

a licensee's test procedures. The general elements of leak test procedures were discussed. The final report is being prepared. The original AECB cost estimate contained a large uncertainty because of the unknown number of techniques being used to leak test sealed radiation sources.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.6.7 **Evaluation of Methods to Calibrate Radiation Survey Meters

Category - NEW File Number: 34-7-2-68
Contractor - Atlantic Nuclear Services Ltd.
(Mr. R.C. Robinson, Mr. N.D. Arbeau)
Fredericton, N.B.

It is proposed to produce a technical reference document that identifies methods and practices currently in use or that may be considered for use by Canadian industry, to satisfy the calibration requirements for radiography survey meters as stipulated in the AEC Regulations, Section 18.15 (1)(b)(ii)(A), (B) and (C). The document will also assess the adequacy of these methods and procedures and, where appropriate, indicate how they may be optimized to satisfy the regulations.

This project is proposed because the Compliance Services and Laboratories Division (CSLD) of the Atomic Energy Control Board (AECB) will be called upon in the near future to evaluate the methods and procedures being used in Canadian industry to satisfy the calibration requirements for radiography survey meters, and the document referred to above would enable the CSLD effectively and consistently to undertake such evaluations.

It is anticipated that the technical reference document produced by this work will be used by the CSLD for compliance purposes to evaluate the methods and procedures used by AECB licensees to calibrate their radiation survey meters. In addition, the document will also be useful to the radiography industry and commercial companies that provide calibration services to radiographers who do not calibrate their survey meters in-house.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00
Actual Spending:	$0.00	$15,659.51	$1,000.00 (Estimate)	$16,659.51 (Estimate)

Contract Completed: No

COMMENTS: The final report is being prepared. The original AECB cost estimate contained a large uncertainty because of the unknown number of laboratory facilities to be visited, manufacturers to be contacted and the total number of assessments of calibration techniques to be made.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

MISSION OBJECT 7 - TRANSPORTATION

85.7.1 Verification of the Performance of Impact Limiting Fins: II

Category - 1* File Number: 34-8-2-2
Contractor - Monserco Limited (Dr. K.G. Torr)
Mississauga, Ontario

It is proposed to conduct a study to investigate the behaviour of impact limiting fins at a variety of impact speeds and impact angles. In addition, it is proposed to construct and test fins made of stainless steel.

Current designs of impact limiting fins are based on tests carried out at one impact velocity and one impact angle. Furthermore, the fins used in all previous tests have been of one material, mild steel; stainless steel has never been tested. This project will test the effectiveness of impact limiting fins made of mild steel and stainless steel at various impact velocities and impact angles.

The results of this project are to be used in writing guidelines for the construction of containers that use impact limiting fins. The information obtained on the stainless steel fins will be used in reviewing currently proposed designs on packages F294, F257 and F271.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$30,000.00	$34,000.00	$0.00	$64,000.00
Actual Spending:	$28,700.00	$35,300.00	$0.00	$64,000.00

Contract Completed: Yes

COMMENTS:

RESULTS: Performance tests on the impact limiting fins of transportation containers showed that, while the shapes of plots of load and energy absorption versus impact velocity were similar to the original ORNL curves, their magnitudes were different. The effect of changing fin material from carbon steel to 304 stainless steel was small, except when the angle of the fin to the line of drop was 30° or greater in which case the fin showed lower absorption properties. The tests for non-square impacts showed peak forces and deformation to be significantly higher than square impact, demonstrating the need for care when using ORNL data for design purposes without additional compliance testing.

EVALUATION: Post Project Evaluation initiated.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.7.1 Doses to Road Transport Workers from Radioactive Materials

Category - 1 File Number: 34-7-2-67
Contractor - MacLaren Engineers Inc. (Mr. B.E. Lawrence)
Toronto, Ontario

It is proposed to measure, over a defined period of time, the doses received by a selected subpopulation of road transport workers. The measurements are to be correlated with the type of radioactive material present in the appropriate shipments. Dose estimates are to be based on personal dosimetry measurements wherever possible; otherwise, the calculated doses will be based on realistic exposure models.

This work is proposed because there are indications that some road transport workers may be receiving exposures which would require their classification as Atomic Radiation Workers. Other incidents point to a need for a comprehensive assessment of the exposures received by road transport workers who are not AECB licensees.

It is anticipated that this work will result in the identification of problem areas (with respect to radioactive materials) in the road transportation industry and in improvements in the compliance and regulatory system. It will also contribute to the IAEA database on risk assessment with respect to road transport workers.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$0.00	$50,000.00

Contract Completed: No

COMMENTS: This project is being administered by the AECB and funded by Transport Canada for a total project cost of $96K.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

MISSION OBJECT 8 - HEALTH PHYSICS

84.8.1 Epidemiological Study of Childhood Genetic Disorders

Category - 1* File Number: 34-7-2-39
Contractor - University of British Columbia (Dr. T.W. Anderson)
Vancouver, B.C.

It is proposed to fund the ongoing epidemiological study of childhood genetic disorders in British Columbia. Genetic disorders among nearly 60,000 live birth cohorts from 1952 to 1982 and nearly 30,000 adults born before 1952 will be analyzed using the most recent classification codes.

This proposal is an update of an earlier British Columbia study which was used extensively by UNSCEAR for risk estimates for genetic disorders. Substantial amounts of data on childhood genetic disorders have been accumulated since the last study was conducted more than a decade ago.

The results of the study are expected to improve the risk estimates for radiation-induced genetic disorders.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$57,000.00	$46,000.00	$72,000.00	$175,000.00
Actual Spending:	$83,518.00	$0.00	$0.00	$83,518.00

Contract Completed: No

COMMENTS: The draft final report has been reviewed and the final report is expected by the end of July 1987.

RESULTS: The preliminary results of the study indicate that 5.0% of the children under 25 years of age in the general population of the province of British Columbia show serious genetic disorders. This consists of 0.4% single gene disorders (autosomal dominant, autosomal recessive and x-linked recessive), 0.2% chromosomal anomalies, and 4.4% multifactorial disorders. The estimate of genetic disorders obtained from this study appears to be somewhat lower than the previous estimates reported in the literature. The reason for such a decrease is the use of revised WHO classification of diseases and omission of disorders in adults greater than 25 years of age. As a consequence, the AECB has sponsored another study (85.8.18) aimed at estimating the genetic disorders among the adult population of British Columbia.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.8.2 Cost of Reducing Risk in Industry and to Society

Category - 1* File Number: 34-9-5-4
Contractor - The DPA Group Inc. (Mr. T. Coape-Arnold)
Toronto, Ontario

It is proposed to fund the ongoing project on the assessment of costs incurred by industries and Canadian society to reduce injuries, diseases and death that result from non-radiological insult.

In order to facilitate the application of differential cost-benefit analysis to the optimization of radiation protection, a value is needed for the minimum amount that should be spent for unit reduction in dose. This minimum amount, expressed, for example in dollars per person-sievert, is commonly called "alpha". "Alpha" values have been derived by other countries from assessments of how much society tends to spend to reduce risk in various activities, and it is now desired to obtain a value for "alpha" based on Canadian data.

The "alpha" value will be used to make a judgement on dose-reduction expenditures in the nuclear industry.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$77,000.00	$18,000.00	$0.00	$95,000.00
Actual Spending:	$76,681.00	$18,029.00	$0.00	$94,710.00

Contract Completed: Yes

COMMENTS:

RESULTS: The purpose of this project was to derive empirical estimates of how much Canadian industry and society in general tend to spend for the reduction of non-radiological health risk. Five case studies were selected for detailed analysis including cervical cancer screening in British Columbia, rail crossing signal improvement in Ontario, oil and gas drilling accident reduction in Alberta, reduction of occupational exposure to lead in Ontario and the purchase and use of children's automotive seat restraints. Estimates of risk reduction were derived from available data bases maintained by the responsible federal and provincial agencies. Estimates of expenditures and details of decision-making processes underlying expenditure decisions were obtained by the personal interview process. Results, in terms of expenditure per unit risk reduction, were prepared using these estimates. The results illustrate a wide range of definitions of risk and expenditures per unit of risk reduction. The study identified methodological constraints in deriving such estimates and highlighted considerations and directions for future research. The study concluded that there was no one measure of spending for risk reduction but a spectrum of such measures. Further estimation of these measures is feasible but should be restricted to cases where confounding factors are minimized or absent. Based on the case studies selected for this project it was concluded that there are likely to be very few other examples of risk reduction which fulfill this requirement.

EVALUATION: One of the two tasks set out in the work statement was successfully completed by the contractor. Completion of the second task was only partially successful as information quantifying risk reduction to society from the actions of Canadian industries was found to be unavailable. However, overall, the project was successful insofar as determining ranges of spending to reduce risk by industry and society. The reasoning behind these expenditures was determined. The results demonstrated that further work in this area would be of little use to the AECB and should not be funded by the AECB.

PUBLICATIONS: INFO 0215, "Assessment of the Cost of Reducing Risk in Industry and to Society".

REVIEW PANEL ACTIVITIES:

84.8.4 Ontario Miners Mortality Study - Phase II

Category - 1* File Number: 34-7-2-35
Contractor - Ontario Ministry of Labour (Dr. J. Muller)
Toronto, Ontario

It is proposed to fund the ongoing investigation of the cause of excess lung cancer among gold miners, to update the mortality analysis for Ontario uranium miners for the period from 1977 to 1981, and to re-evaluate the risk of lung cancer per unit exposure.

This is an extension of the Phase I study where excess lung cancer among gold miners was identified, and further investigation of the cause was recommended. Because several uranium miners had previous gold mining experience, it is also necessary to investigate the contribution of gold mining experience on lung cancer incidence among uranium miners.

The results of the study will be used to improve the risk estimates for radiation-induced lung cancers. (A joint study with the Workers' Compensation Board of Ontario and Ontario Ministry of Labour.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$187,000.00	0.00	$0.00	$187,000.00
Actual Spending:	$133,941.60	$53,000.00	$0.00	$186,941.60

Contract Completed: No

COMMENTS: As a part of the Phase II study, a final report on the gold miners' mortality was received in July 1986. Additionally, a draft final report of the mortality analysis for the uranium miners is expected in May 1987.

RESULTS: The results of the gold miners mortality study indicated that arsenic and fibrous materials present in the ore body of the gold mines might be the cause of observed excess lung cancer among the gold miners. However, at this stage, no attempt will be made to examine the quantitative relationship between the incidence of excess lung cancer and exposure to arsenic and fibrous materials in the gold ore body. Preliminary results of the uranium miners mortality study indicate that the risk estimate for lung cancer due to radon daughter exposure is not very different from the values derived from the previous analysis (Phase I). The study also suggested a multiplicative interaction between smoking and radiation exposure with regard to induction of lung cancer. The final report of the Ontario Uranium Miners Mortality Study (Phase II) is expected by the fall of 1987.

EVALUATION:

PUBLICATIONS: "Study of Mortality in Ontario Gold Miners 1955-1977", Ontario Ministry of Labour, Workers' Compensation Board of Ontario, Atomic Energy Control Board, July 1986, Toronto, Canada.

REVIEW PANEL ACTIVITIES:

84.8.5 Newfoundland Fluorspar Miners Mortality Study

Category - 1* File Number: 34-4-2-18
Contractor - Statistics Canada (Mr. H. Morrison)
Ottawa, Ontario

It is proposed to fund the ongoing mortality analysis of Newfoundland fluorspar miners by extending the mortality analysis from 1978 to 1984 and by examining the smoking and dietary histories of the miners.

This study is proposed in order to extend the mortality analysis from 1978 to 1984, and to allow the use of revised exposure estimates to calculate the risk of lung cancer from radon daughter exposure. The revised risk estimates will also take smoking and dietary factors into account.

It is anticipated that the study will improve the risk estimates for lung cancer among miners exposed to radon daughters. (A joint study with Statistics Canada and the Department of National Health and Welfare.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$148,000.00	$15,000.00	$0.00	$163,000.00
Actual Spending:	$146,525.92	$23,474.08	$0.00	$170,000.00

Contract Completed: No

COMMENTS: A draft final report of the study was reviewed and the final report is expected by the end of July 1987. The original estimate included the projected cost of the study of genetic disorders in adults; now this part of the study appears as 85.8.18.

RESULTS: Preliminary results indicate that the risk of lung cancer among the fluorspar miners is approximately 6 per million person-years per WLM, which is less than half the value reported in a previous study of the same miners. The decrease in risk estimates is attributed mainly to improved exposure estimates. This risk estimate is comparable to the values obtained from the studies of Ontario and U.S. uranium miners.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.8.6 Ontario Miners 'Alive' Follow-Up Feasibility Study

Category - 1* File Number: 34-7-2-28
Contractor - Statistics Canada (Ms. M. Smith)
Ottawa, Ontario

It is proposed to fund the ongoing feasibility study of 'alive' follow-up of Ontario miners, by using available information from Canadian income tax data, Canada Pension Plan records and other suitable files.

This study is proposed because of the need to examine the uncertainties involved in 'alive' assumptions using various data files. In an occupational mortality study, names of persons in nominal rolls are usually matched against the names in the Mortality Data Base to ascertain deaths. Those who are not matched are usually assumed to be 'alive', and there may be some uncertainties in this assumption because some of these 'alive' persons might have died outside the country or been lost for follow-up purposes.

The results of the study are expected to improve the quality of death searches in occupational mortality studies and hence the risk estimates for radiation-induced cancers. (A joint study with Statistics Canada, Ontario Ministry of Labour and Workers' Compensation Board of Ontario.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$113,000.00	$15,000.00	$0.00	$128,000.00
Actual Spending:	$107,955.50	$8,182.42	$0.00	$116,137.92

Contract Completed: No

COMMENTS: A draft final report has been received. The final report is expected in August 1987.

RESULTS: Preliminary results of the study indicate that, of the 27,750 Ontario miners who were assumed to be alive for the purpose of mortality analysis, only 1,020 miners remained untraced. Among these there could be an admixture of deaths outside Canada and of persons who are still alive but who did not file income tax returns during the period of the study. The study also indicated that the use of the Canadian Mortality Data Base is adequate to derive satisfactory risk estimates from mortality studies related to radiation exposures.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.8.7 Epidemiology of Lung Cancer Mortality in Canadian Mining Communities

Category - 1* File Number: 34-7-2-42
Contractor - National Health & Welfare (Dr. Y. Mao)
Ottawa, Ontario

It is proposed to fund the ongoing case-control pilot study of lung cancer deaths in uranium and non-uranium mining towns across Canada in which lung cancer mortality has been shown to be significantly elevated.

The study is proposed in order to attempt to find out to what extent various factors in the home and the workplace were responsible for excess cancer among miners and other residents of mining communities.

It is anticipated that the results of this study will be used to improve risk estimates for radiation-induced lung cancers. (A joint study with Statistics Canada and Health and Welfare Canada.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$75,000.00	$13,000.00	$0.00	$88,000.00
Actual Spending:	$57,076.24	$12,467.20	$0.00	$69,543.44

Contract Completed: No

COMMENTS: Work completed. Final report in preparation. The completion of this project was delayed due to difficulties in obtaining and processing monitors for measuring radon exposures in the homes of the participants in this case-control study. The actual spending was less than the estimated because of reduced costs associated with acquiring the dose information from radon exposure in individual homes.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.8.8 Study of Health Effects on Central Nervous System following In Utero Exposure to Ionizing Radiation

Category - 1* File Number: 34-7-2-44
Contractor - Bio-Research Laboratories Ltd. (Dr. G. Losos)
Senneville, Quebec

It is proposed to fund the ongoing full-scale study of the effects on the central nervous system of rats and monkeys following in utero exposure to ionizing radiation at different stages of gestation. This study is based on the recommendation of a feasibility study completed in FY 84/85.

This project is proposed because it is expected that an increasing number of young women will seek employment in the Canadian nuclear industry, where, in some cases, exposure of embryos or fetuses might occur. Very little information is available in the literature about the effect of in utero irradiation on the function and structure of the brain, and the proposed study will help in the understanding of the problem.

It is anticipated that the results of the study will be used to improve risk estimates for radiation-induced developmental defects.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$31,000.00	$150,000.00	$150,000.00	$331,000.00
Actual Spending:	$21,797.00	$0.00	$0.00	$21,797.00

Contract Completed: Yes

COMMENTS: Spending for FY 86/87 and future years has been postponed (see Review Panel Activities).

RESULTS: The report of the feasibility study recommended a full-scale study on rats and monkeys, using 2-deoxyglucose as a biochemical tracer to quantify the activity of different parts of the brain as a function of in utero dose and the stage of gestation.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H1: At the suggestion of the review panel, the full-scale study was postponed until the outcome of a feasibility study on developmental defects among Canadians (85.8.7).

84.8.9 Ontario Miners SIN Evaluation Study

Category - 1* File Number: 34-7-2-32
Contractor - Statistics Canada (Ms. M. Smith)
Ottawa, Ontario

It is proposed to fund the ongoing investigation on the effectiveness of the use of supplementary information from the Social Insurance Number data file in the analysis of occupational mortality among miners.

The study should indicate whether or not the use of SIN information would substantially improve the number of successful linkages of mortality and hence the accuracy of epidemiological studies.

It is anticipated that the results of the study will be used to improve the risk estimates for radiation-induced cancer mortality among various occupationally exposed groups. (A joint study with Statistics Canada and Ontario Ministry of Labour.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$9,000.00	0.00	$0.00	$9,000.00
Actual Spending:	$9,281.17	$0.00	$0.00	$9,281.17

Contract Completed: Yes

COMMENTS: The final report has been received.

RESULTS: The results of the study indicated that the use of supplementary information in the Social Insurance Number file will marginally improve the death search used in conventional epidemiological studies of radiation-induced health effects.

EVALUATION: The Post Project Evaluation has been initiated.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.8.10 The Canadian National Dose Registry Study

Category - 1* File Number: 34-7-2-38
Contractor - Statistics Canada (Ms. M. Smith)
Ottawa, Ontario

It is proposed to provide funding for the ongoing project to conduct an epidemiological study of cancer mortality among some 300,000 Canadians occupationally exposed to low levels of ionizing radiation, by developing a suitable linkage between the Canadian National Dose Registry and the Canadian Mortality Data Base.

This study is intended to find out whether there is any excess cancer mortality among certain groups of workers, such as Nuclear Medicine Technicians and Radiographers, who have not been studied so far in sufficient detail. This study of 300,000 radiation workers is likely to provide further information towards a better understanding of the dose-response relationship for low doses of ionizing radiation.

It is anticipated that the results of this study will be used to verify risk estimates for radiation-induced cancer mortality. (A joint study with the Department of National Health and Welfare and Statistics Canada.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$120,000.00	$95,000.00	$110,000.00	$325,000.00
Actual Spending:	$124,204.90	$46,126.47	$154,668.63 (Estimate)	$325,000.00 (Estimate)

Contract Completed: No

COMMENTS:

RESULTS: The following preliminary results have been obtained: matching the Social Insurance Number (SIN) to the National Dose Registry (NDR); performing numeric linkage resolutions; merging results of numeric linkages to complete the Master Identification File; adding corrections to the Master Identification File; collapsing the records and filling in data; adding AECL records to the NDR; testing the NYSIIS (name encoding scheme) internal linkage and death linkage; and creating an analysis file.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

84.8.11 Study of the Health Effects of Inhaled Uranium Ore Dust

Category - 1* File Number: 34-4-2-19
Contractor - MacLaren Plansearch Inc. (Dr. A. Van de Vooren)
Toronto, Ontario

It is proposed to provide funding for the ongoing project to study the health effects (cancer mortality and histological defects) on experimental animals exposed to different concentrations of long-lived radioactive dust, such as those encountered in the uranium mines in Ontario and Saskatchewan.

The study is proposed because Canadian uranium miners are occupationally exposed to long-lived dust (containing uranium, thorium and their long-lived daughters), and the contribution of this exposure to the incidence of cancer is not fully understood.

The results of this study will be used to interpret the health effects of long-lived dust on uranium miners and to develop regulatory guidelines for controlling exposures to long-lived radioactive dust.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$106,000.00	$135,000.00	$589,000.00	$830,000.00
Actual Spending:	$79,037.53	$78,880.79	$671,801.68 (Estimate)	$829,720.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. The experimental procedures for the preliminary studies have been refined, with the assistance of the Review Panel. The aerosol generation and monitoring equipment has been purchased and is being tested. An adequate supply of high grade uranium ore has been secured and is being ground to the appropriate size range. Suppliers of inhalation equipment have been identified. The layout of the inhalation and animal care facilities has been designed.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H3: The review panel was consulted in order to finalize the experimental protocol, most specifically in regard to the strain of animal to be used, the determination of exposure conditions for the main study and the need for a preliminary study aimed at ensuring that the animals would be able to withstand actual exposure conditions. The contractors, in consultation with the review panel, carried out an evaluation of the parameters, which would be needed to interpret the final results of the main study.

84.8.12 Study of the Distribution of Fatal Risk in "Safe" Industries

Category - 1* File Number: 34-9-5-4
Contractor - Social Data Research Ltd.
(Ms. C.K. Davis, Dr. W.F. Forbes, Ms. L.M. Hayward)
Hamilton, Ontario

It is proposed to fund the ongoing study of the statistical distribution of fatal risk in those Canadian industries which are recognized as having a high standard of safety.

The average risk of radiation exposure in the nuclear industry is often compared with the average fatal risk in non-nuclear industries which are considered to be "safe". However, it is not known whether the ratio of the maximum to the average risk due to radiation is comparable to the corresponding risk ratios in "safe" industries.

It is anticipated that the results of this study will help in judging whether or not the dose limits for radiation workers represent too high an individual risk.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$50,000.00	0.00	$0.00	$50,000.00
Actual Spending:	$48,999.66	$0.00	$0.00	$48,999.66

Contract Completed: Yes

COMMENTS:

RESULTS: The results of this contract are included in the additional work on the project - see 86.8.17.

EVALUATION: The evaluation of this study is presented in the summary for project 86.8.17.

PUBLICATIONS: INFO 0206, "The Distribution of Fatal Risk in Ontario Industries".

REVIEW PANEL ACTIVITIES:

84.8.13 Epidemiological Study of Thyroid Cancer from I-131 Exposure

Category - 1* File Number: 34-7-2-31
Contractor - Alberta Cancer Board (Dr. G.B. Hill)
Edmonton, Alberta

It is proposed to fund the ongoing epidemiological study of thyroid cancer among Canadians who were exposed to radioactive iodines during diagnostic examinations.

This project is proposed because risk estimates for radiation-induced thyroid cancer are largely based on the incidence among those exposed to X-radiation. There is some controversy as to whether or not the same doses of I-131 and X-radiation are equally effective for the induction of thyroid cancer. A pilot study, jointly funded by the Alberta Cancer Board and the AECB, has recommended a full-scale study at the national level to investigate the relative biological effectiveness of X-radiation and I-131.

The results of the study are expected to refine the risk estimates for radioiodine-induced thyroid cancers, and to determine whether or not equal (thyroid) doses of I-131 and X-radiation are equally effective in the induction of thyroid cancers. (A joint study with Alberta Cancer Board and NHW. The AECB share is one-third of the total cost.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$60,000.00	$50,000.00	$21,000.00	$131,000.00
Actual Spending:	$60,000.00	$0.00	$0.00	$60,000.00

Contract Completed: Yes

COMMENTS: The full-scale study is scheduled for initiation in FY 87/88 (see 86.8.15). The original cost estimate included that of the full-scale study, which now appears under 86.8.15.

RESULTS: A feasibility study has been received, recommending that a full-scale study be carried out at the national level, to be funded equally among the AECB, NHW and the Alberta Cancer Board.

EVALUATION: Post Project Evaluation is underway.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H2: The review panel agreed with the recommendation of the contractor to fund a full-scale study at the national level.

84.8.14 **Measurement of the Thickness of Bronchial Epithelium

Category - 1 File Number: 34-7-2-46
Contractor - University of Manitoba (Dr. D.H. Bowden)
Winnipeg, Manitoba

It is proposed to measure the depth of basal cells and the thickness of cilia and mucous layers covering the human epithelium of the tracheo-bronchial region to identify the cells that make up the epithelial walls, and to indicate their relative number in the cell population. Measurements of the various parameters will be made on biopsy and autopsy samples.

The study is expected to improve the accuracy of the various anatomical parameters used in lung dose calculations. Currently available data on the above anatomical parameters are based only on a single study which is known to have many uncertainties.

It is anticipated that the more accurately determined parameters obtained from this study will be used in the calculation of lung doses due to inhaled radon and thoron daughters and long-lived radioactive dust.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$55,000.00	$115,000.00
Actual Spending:	$0.00	$31,029.71	$91,341.29 (Estimate)	$122,371.00 (Estimate)

Contract Completed: No

COMMENTS: Progress to date: Major emphasis has been placed on the investigation of bronchial epithelial thickness. Lungs from 20 surgical cases have been fixed by airway perfusion and sliced sequentially into 0.5 cm sections. From each case, multiple bronchi have been selected and embedded in methacrylate. Fourteen cases have been cut and stained. For three cases, preliminary measurements of bronchial size and epithelial thickness, number of basal cells per bronchus, thickness and extent of squamous metaplasia and hyperplasia, and assessment of non-ciliated epithelium have either been made or are in the process of being carried out.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: The panelists reviewed several documents, including two progress reports, and attended two meetings at the AECB headquarters. The panelists made several suggestions concerning the conduct of the work which were gratefully acknowledged and accepted by the contractor.

84.8.15 Measurement of RBE for Tritium for Myeloid Leukemia

Category - 1* File Number: 34-7-2-43
Contractor - Atomic Energy of Canada Limited (Dr. J.R. Johnson)
Chalk River, Ontario

It is proposed to fund the ongoing laboratory experiment to measure the Relative Biological Effectiveness of tritium beta rays for the induction of myeloid leukemia in mice.

The study is proposed because of the concern as to whether or not a given dose of tritium beta rays is equally as effective as the same dose of chronic 200 kVp X-rays, acute 200 kVp X-rays and chronic Co-60 gamma rays for the induction of myeloid leukemia. A feasibility study completed in FY 84/85 has recommended a full-scale 5-year study on CBA/H mice.

It is anticipated that the results of the study are expected to improve the estimate of the quality factor (QF) for tritium beta rays. (A joint study with AECL, Ontario Hydro, Hydro Quebec and NBEPC. The total cost of the study is 1.2 million dollars and the AECB share is $343K. This project was approved by the Board on September 19, 1985, BMD 85-130.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$31,000.00	$51,000.00	$261,000.00	$343,000.00
Actual Spending:	$23,000.00	$71,370.90	$251,569.10 (Estimate)	$345,940.00 (Estimate)

Contract Completed: No

COMMENTS: The breeding colony has been established. After the breakdown of the 300 KVp generator, irradiations are being conducted using highly-filtered 150 KVp X-rays (not anticipated to undermine the validity of the results), while injections of tritiated water have also been initiated.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: The panelists reviewed four Quarterly Progress Reports and one "Specialist Report", and attended one meeting at the AECB headquarters. One panelist raised three points at the meeting which could significantly impact on the study design, and on the manpower requirements for this work. The first of these referred to the variability of the spontaneous rate of incidence of myeloid leukemia in the CBA/H mice; the second was concerned with the desirability of making at least two and possibly more than two checks per day of the condition of the test animals; and the third discussed the importance of having a qualified pathologist on the study team. Further investigation of these matters is being undertaken by the contractor.

84.8.18 Doses to Technologists from Nuclear Medicine Imaging Procedures

Category - 1* File Number: 34-7-2-47
Contractor - Pasqua Hospital (Dr. R. Sloboda)
Regina, Saskatchewan

It is proposed to measure the distribution of radiation dose to nuclear medicine technologists in the course of their work during imaging procedures.

This work is proposed because it was recently determined that the whole body exposure from patient handling during imaging procedures accounts for more than 50 percent of the total dose received during the entire procedure. Information is required on the procedural distribution of radiation doses received during patient handling so that improvement could be made on procedural designs in order to reduce doses to nuclear medicine technologists.

It is anticipated that the results of the study would be used to make procedural changes in order to reduce doses to nuclear medicine technologists.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$15,000.00	0.00	$0.00	$15,000.00
Actual Spending:	$14,175.00	$500.00	$0.00	$14,675.00

Contract Completed: Yes

COMMENTS:

RESULTS: Radiation exposures incurred by nuclear medicine technologists during diagnostic imaging and gamma camera quality control (QC) were measured on a procedural basis over three-month period using a portable, low-range, self-reading ion chamber. A total of more than 400 measurements were made for 15 selected procedures. From these, mean procedural exposures and standard deviations were calculated. The results show that daily flood phantom QC, at 0.58 mR, and gated cardiac studies, at 0.45 mR, were the two greatest sources of exposure. Other procedures resulted in exposures varying roughly from 0.10 to 0.20 mR. Difficult patients were responsible for a doubling of technologist exposure for many procedures. Standard deviations were large for all procedures, averaging 65% of the mean values. Comparison of technologist exposure inferred from the procedural measurements with the time coincident collective dose equivalent recorded by the TLD service of the Bureau of Radiation and Medical Devices indicates that approximately half of the collective technologist exposure arose from patient handling and flood QC.

EVALUATION: The objectives of the project were met. The authors showed considerable expertise in the field of nuclear medicine. The report showed the ability of the authors to do methodical work including skills requiring coordination from various working units in a hospital. Good value for money was obtained from this project. Since the doses to nuclear medicine technologists were found to be relatively small, no regulatory action will be undertaken.

PUBLICATIONS:

1) INFO 0199, "Radiation Exposures to Technologists from Nuclear Medicine Imaging Procedures".

2) "Technologist Radiation Exposures from Nuclear Medicine Imaging Procedures", Sloboda, R.S., Schmid, M.G., Willis, C.P., Journal of Nuclear Medicine Technology, Vol. 15, Number 1, March 1987, pp. 16-24.

REVIEW PANEL ACTIVITIES:

85.8.2 Study of the Size Change of Inhaled Submicron Aerosols

Category - 1* File Number: 34-4-2-24
Contractor - University of Toronto (Prof. C.R. Phillips)
Toronto, Ontario

It is proposed to continue to study, experimentally, the influence of the change of humidity and temperature on the size of inhaled radon and thoron progeny-bearing submicron aerosols as they pass from the open atmosphere through the respiratory system.

The dose delivered to the lung by inhaled radon or thoron progeny is strongly dependent upon the size of the particles. For an identical exposure to radon daughters, the dose to the lung doubles when the particle size decreases from 0.2 to 0.1 micrometre. Working level month-to-sievert conversion factors found in the literature (ICRP 32, NEA Experts Report on Dosimetry Aspects of Exposure to Radon and Thoron Daughter Products) are based on the assumption that the carrier aerosol has an activity median aerodynamic diameter (AMAD) of 0.15 to 0.3 micrometre. However, aerosol measurements in uranium mines indicate that radon daughter carrier aerosols generally have an AMAD of 0.1 micrometre or less. If the change in humidity and temperature which the aerosol encounters when it is inhaled does not affect its AMAD, higher exposure-to-dose conversion factors than those found in the literature should be used.

It is anticipated that the findings of this study will narrow the range of current exposure-to-dose conversion factors and hence will increase the accuracy of dose calculations.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$60,000.00	$30,000.00	$0.00	$90,000.00
Actual Spending:	$65,874.39	$23,406.59	$0.00	$89,280.98

Contract Completed: No

COMMENTS: Work completed. Final report in preparation. Preliminary results indicate that the aerodynamic diameters of NaCl and kerosene combustion aerosols grow by a factor of 1.9 and 1.3 respectively when relative humidity increases from 35% to 100% and temperature increases from 20°C to 37°C.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.3 **Comparison of the Rationale Used in Setting Occupational Limits for Radiation and Hazardous Chemical Substances

Category - 1 File Number: 34-7-2-58
Contractor - Monserco Limited (Dr. D.M. Halten)
Mississauga, Ontario

It is proposed to examine the rationale used in setting occupational standards for hazardous chemical substances and compare it with the rationale used for setting dose limits for ionizing radiation.

The study is proposed because there is a lack of comparative understanding of the rationale and the philosophy behind setting occupational standards for radiological carcinogens and hazardous chemical substances in the workplace.

It is anticipated that the results of the study will enable the AECB to judge whether or not the dose limits for ionizing radiation are based on a more or less sound rationale than the corresponding limits for hazardous chemical substances in the workplace.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$35,000.00	$0.00	$35,000.00
Actual Spending:	$0.00	$34,391.25	$0.00	$34,391.25

Contract Completed: Yes

COMMENTS:

RESULTS: The introduction of the study dealt with the history and development of the regulations, recommendations, guidelines and standards as they apply to exposure, chemical and radioactive, in the workplace. Ten chemicals which create significant occupational hazard were reviewed. They were toluene diisocyanate, hydrogen fluoride, n-hexane, carbon disulphide, cadmium, inorganic mercury, cobalt, nitroglycerol, silica and vinyl chloride. Each is discussed under the headings of physiological intake and elimination in humans, characteristics of acute and chronic toxicity, sites of occupational exposure and rationale for limits of such exposure. For hazardous chemical substances, the American Conference of Governmental Industrial Hygienists (ACGIH) is the origin of recommended Threshold Limit Values (TLVs) which many jurisdictions have written into their regulatory framework. In Canada standards for ionizing radiation sources, particles or vapour, generally arise from deliberations and recommendations of committees such as the International Commission on Radiological Protection. The growth of knowledge of injury due to ionizing radiation (X-rays) from the beginning of the century formed the basis of the recommended maximum occupational levels of airborne radionuclides. Having set out industrial standards for exposure to hazardous substances and

radionuclides, the report made a detailed comparison. Exposure limits to ionizing radiation are sufficiently low to remove the appearance of directly related injury. It is expected however that low level exposure may have a stochastic effect, that is, there is the possibility of a slightly increased incidence of neoplasms in a large exposed population, but numbers will be too small to be able to attribute any particular case to the exposure. TLVs on the other hand, depending on the particular chemical, may be high enough in the workplace to permit some directly-related signs or symptoms in the exposed individual.

EVALUATION: Post Project Evaluation is underway.

PUBLICATIONS: INFO 0214, "Comparison of the Rationale Used in Setting Occupational Exposure Standards for Ionizing Radiation and Hazardous Chemical Substances".

REVIEW PANEL ACTIVITIES:

85.8.4 Epidemiological Study of Childhood Cancers Due to Parental Irradiation

Category - 1* File Number: 34-7-2-53
Contractor - University of Ottawa (Dr. S. Raman)
Ottawa, Ontario

It is proposed to fund the ongoing pilot study to examine the feasibility of a full-scale epidemiological study of radiation-induced childhood cancers among Canadians.

With the proposed changes in the dose limits for female atomic radiation workers, increasing numbers of young women are expected to seek employment in various activities where they might receive in utero exposures. Since a positive association between childhood cancers (mainly leukemia, thyroid and brain cancers) and low-level radiation has been reported in some countries, it is important to investigate this relationship among Canadian children and to determine to what extent other maternal factors, such as smoking, dietary pattern and intake of drugs during pregnancy, influence the relationship.

It is anticipated that the results of the pilot study will enable the AECB to determine the feasibility of a comprehensive case-control study. The comprehensive study is expected to result in the improvement of the risk estimates for radiation-induced cancers.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$25,000.00	$41,000.00	$0.00	$66,000.00
Actual Spending:	$6,810.65	$59,416.35	$0.00 (Estimate)	$66,227.00 (Estimate)

Contract Completed: No

COMMENTS: A draft final report is expected by the end of July 1987.

RESULTS: Preliminary results of the study indicated that there were (i) considerable difficulties in obtaining personal identifying information and (ii) uncertainties in the estimation of radiation exposure received in utero and during early childhood.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H2: The review panel of Provincial Epidemiologists reviewed the work statement and subsequent progress of the study. Such a review has resulted in the improvement of the method used for the selection of controls and for the estimation of exposures from medical applications of ionizing radiation.

85.8.6 Revision of Name Encoding Scheme (NYSIIS) for Use by Canadian Epidemiological Studies

Category - 1* File Number: 34-7-2-50
Contractor - Statistics Canada (Ms. M. Smith)
Ottawa, Ontario

It is proposed to continue the funding of this project which is examining the feasibility of revising the currently used computer code of name encoding scheme (NYSIIS) for Canadian names and phonetics using Ontario Miners' Mortality data.

A number of epidemiological studies of radiation-induced cancers reveal that 2-10% of mortality searches are lost because the currently used name encoding scheme developed by New York State (NYSIIS) is inadequate for certain Canadian surnames. A revised name encoding scheme might therefore be necessary to improve the accuracy of the mortality search.

The results of the study would be used to determine whether or not a revised name encoding scheme should be developed and used in all Canadian epidemiological studies of radiation-induced cancers.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$30,000.00	$37,000.00	$0.00	$67,000.00
Actual Spending:	$13,897.19	$38,089.05	$25,403.76 (Estimate)	$77,390.00 (Estimate)

Contract Completed: No

COMMENTS:

RESULTS: The following preliminary results have been obtained: several revisions to the NYSIIS code have resulted in the reduction of missing matches; a subset of the Ontario Miners' Mortality file is being used as a test file. Further refinements to the NYSIIS code are being considered.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.7 **Epidemiological Study of Radiation-Induced Developmental Defects among Canadians

Category - 1 File Number: 34-7-2-54
Contractor - University of British Columbia
(Dr. T.W. Anderson, Dr. S. Shepps)
Vancouver, B.C.

It is proposed to fund the pilot study to examine the feasibility of a full-scale epidemiological study of developmental defects among Canadians who received in utero irradiation. (Cancer is not considered to be a developmental defect.)

With the revision of dose limits for female atomic radiation workers increasing numbers of young women are expected to seek employment in the nuclear industry and in other activities where exposure of an embryo or fetus might occur. This exposure might result in increased incidence of radiation-induced developmental defects. The currently available risk estimate of 10^{-1} per Sv for developmental defects has a number of uncertainties associated with it and, therefore, further studies are needed. No comprehensive epidemiological study has ever been undertaken in Canada to obtain the additional information which would improve the risk estimates for radiation-induced developmental defects.

It is anticipated that the results of the study will enable the AECB to determine the feasibility of a full-scale study. Such a full-scale study, if it is feasible, is likely to result in the improvement of risk estimates for radiation-induced developmental defects.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$20,000.00	$45,000.00
Actual Spending:	$0.00	$25,000.00	$37,026.00 (Estimate)	$62,026.00 (Estimate)

Contract Completed: No

COMMENTS: The contractor's estimate was higher than the original estimate by the AECB staff because of additional expenditures involved in data collection from individual cases and controls.

RESULTS: A satisfactory questionnaire was developed to collect information on developmental abnormalities and radiation exposures.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H1: The design of the study was reviewed by the review panel. Such review has resulted in the incorporation of some changes in the histological examination of cases to ensure correct diagnosis of the disease. The review panel has also recommended a delay in the initiation of another related study (85.8.13).

85.8.8 **Comparison of the Techniques Used in Estimating Past Exposures to Radon Daughters in Canadian Mines

Category - 1 File Number: 34-4-2-48
Contractor - Senes Consultants Ltd. (Dr. D. Chambers)
Willowdale, Ontario

It is proposed to examine and compare the techniques used to evaluate past exposures to radon daughters in various Canadian uranium and non-uranium mines.

At present it is not known whether the techniques and assumptions used to estimate past exposures to radon daughters in the various Canadian mines, such as those in Newfoundland, Ontario and Saskatchewan, are similar to one another or different. As a result it is difficult to compare the risk estimates obtained from one study to another.

The results of the study would enable the AECB to compare and improve the risk estimates obtained from the various Canadian studies.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$45,000.00	$0.00	$45,000.00
Actual Spending:	$0.00	$12,670.00	$46,592.00 (Estimate)	$59,262.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. Survey and review of North American data completed. Review of European data in progress. The actual cost will exceed the estimated cost because of the later decision to include data from non-Canadian sources.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.11 **Cost-Effectiveness of Reduction of Off-Site Dose

Category - 1 File Number: 34-2-4-35
Contractor - Atlantic Nuclear Services Ltd. (K. Scott)
Fredericton, N.B.

It is proposed to perform a cost-effectiveness analysis to examine alternate nuclear power plant effluent control technologies, their costs, and benefits in terms of reduced off-site dose.

This project is proposed because the AECB has been using a target of one percent of licensed emission limits for liquid and gaseous effluents for several years without verifying, through cost-effectiveness analysis, whether further measures to reduce radiation doses to persons off-site might be reasonably achievable.

It is anticipated that the information obtained from this study will help the Board decide whether additional measures to reduce off-site radiation doses should be required, and whether the current design and operating target (1%) is still appropriate in light of any technological advances that have occurred since this target was established.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$0.00	$50,000.00
Actual Spending:	$0.00	$25,000.00	$23,390.00 (Estimate)	$48,390.00 (Estimate)

Contract Completed: No

COMMENTS: The draft final report is in preparation.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel S5: The Panel was set up to advise on the scope, direction and content of the project. The work proper of the Panel was therefore completed on commencement of the contract. However, the Panel will be requested to comment on the results of the contract, once the final report has been submitted.

85.8.12 Measurement of Absorbed Fraction of Ingested Uranium in Humans

Category - 3

It is proposed to determine the absorbed fraction (f_1) of ingested dietary uranium in humans, including those living in uranium mining communities, by measuring the content of uranium in their diet and in their fecal and urinary excretions.

The currently used annual limit on intake (ALI) for uranium by ingestion is derived using a value of 0.05 for the absorbed fraction (f_1) of ingested uranium. This fraction is known to have a number of uncertainties, and more measurements should be done to improve its accuracy.

The results of the study are expected to improve the value for f_1 and hence the estimate of the ALI for uranium.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$20,000.00	$80,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.13 Full-Scale Study of Health Effects on Central Nervous System following In-Utero Exposure

Category - NEW File Number: 34-7-2-44

It is proposed to fund a full-scale study of the health effects on the central nervous system (CNS) of experimental animals (rats and monkeys) following in utero exposure to ionizing radiation at different stages of gestation.

It is anticipated that an increasing number of young women will seek employment in the Canadian nuclear industry, where, in some cases, exposure of embryos or fetuses may occur. Very little information is available in the literature about the effect of in utero irradiation on the function and structure of the central nervous system. A feasibility study (84.8.8) completed in 1986 recommended a full-scale study to make quantitative estimations of the risk of health defects on the CNS following in utero irradiation taking dose, dose rate, and the stage of gestation into account. The Review Panel is also awaiting the results of 85.8.7 from which neuro-histological information (from humans) is needed in order for the present study to commence.

The results of the full-scale study will be used to improve risk estimates for radiation-induced developmental defects.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$150,000.00	$150,000.00	$300,000.00

Contract Completed: N.A.

COMMENTS: At the recommendation of the review panel (H1), the initiation of this study was delayed until the completion of a related study "Epidemiological Study of Radiation-Induced Developmental Defects among Canadians (85.8.7)".

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H1

85.8.15 A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities

Category - 1* File Number: 34-7-2-52
Contractor - Atomic Energy of Canada Limited (Dr. A. Petkau)
Pinawa, Manitoba

It is proposed to continue the funding of this feasibility study which involves identifying and determining the occupational exposures to non-radiological substances at a number of Canadian nuclear facilities (e.g., Whiteshell Nuclear Research Establishment, Pickering Nuclear Generating Station, Eldorado Nuclear Ltd., Canadian General Electric Co.).

This study is being proposed because workers at Canadian nuclear facilities might be exposed to a number of non-radiological carcinogens. These carcinogens and their concentrations have not been accounted for in a number of epidemiological studies as potential factors in the induction of cancer among radiation workers. Before these carcinogens are properly accounted for in epidemiological studies, it is necessary to identify them and to determine their concentrations in the current radiation working environment. These concentrations may also provide the basis for historical estimates (of the concentrations of these carcinogens) relevant to the period of the epidemiological studies.

It is anticipated that the results of the study will demonstrate whether or not it is feasible to identify and to determine the concentrations of non-radiological substances at Canadian nuclear facilities. This should enable the AECB to carry out epidemiological studies on the potentiation of non-radiological substances as possible synergistic factors in the induction of cancer among workers in the current radiation working environment. (The original project 85.8.5 has been divided into two projects 85.8.15 and 85.8.16.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$14,000.00	$32,000.00	$0.00	$46,000.00
Actual Spending:	$4,000.00	$37,000.00	$5,000.00 (Estimate)	$46,000.00 (Estimate)

Contract Completed: No

COMMENTS: A list of non-radiological substances in use at the various Canadian nuclear facilities has been compiled and efforts are being expended on the feasibility of determining whether the existing measurement regimes can provide adequate information on the health effects of these non-radiological substances to workers at those facilities.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.16 Standardization of Individual Identifying Information for Health Record Keeping Methodology

Category - 1* File Number: 34-7-2-59
Contractor - Statistics Canada (Ms. M. Smith)
Ottawa, Ontario

It is proposed to continue the funding of the development and evaluation of a standard health record keeping methodology for employees of AECB licensees. This methodology will provide a standard for the collection of adequate individual identifying information to facilitate long-term follow-up of licensees' employees exposed to radiological and non-radiological hazardous agents for detection of possible health risks or delayed harm. The methodology will then be tested and evaluated by means of a pilot project, with a view to recommending procedures for the implementation, update, and maintenance of information related to individual identifiers.

This project is proposed because adequate personal identification captured and stored in a cost-effective retrievable form will facilitate future follow-up studies. Presently, it is often found during the linkage of data files in epidemiological studies (including AECB-sponsored studies, such as the Newfoundland Fluorspar Miners and the National Dose Registry workers) that inadequate individual identifying information is being maintained for current and past employees. The absence of complete and a sufficient number of identifiers makes it difficult and costly, or in many other cases impossible, to carry out long-term follow-up and record linkage studies for detection of health risks. The pilot project, for the testing and evaluation phase, is being proposed because it will ensure that the design, documentation and procedures developed are sufficient for the implementation and maintenance of a health record keeping system for AECB licensees who supply information on radiation doses to the National Dose Registry. The pilot project is expected to be carried out in collaboration with a licensee, likely Atomic Energy of Canada Limited.

It is anticipated that the results of the study will facilitate and encourage adequate on-going individual record keeping for the preparation of current and past employee nominal rolls. Since a standard record keeping method will make all licensees' files compatible, data analyses among the various files should not only be cheaper and more thorough, but also comparable. The standard method should facilitate periodical epidemiological studies, for example, as study populations age. It may also allow the study of synergisms among radiation and chemical agents, or among radiation and other factors (medical history, lifestyle, geographic location, etc.). The results may also form the basis of an unambiguous identification of the individual in conjunction with the collection of radiological and non-radiological exposure histories and work histories. These will allow for subsequent follow-up, by the AECB, of health outcomes (mortality, morbidity, and genetic effects) and will be of use for reporting purposes to registries (dose, exposure or disease), and for other legislative or regulatory requirements. (The original project 85.8.5 has been divided into two projects 85.8.15 and 85.8.16.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$30,000.00	$45,000.00	$0.00	$75,000.00
Actual Spending:	$23,773.71	$32,713.26	$20,513.03 (Estimate)	$77,000.00 (Estimate)

Contract Completed: No

COMMENTS:

RESULTS: A comprehensive employee identification form and its accompanying explanatory notes have been developed by Statistics Canada. This form is being tested at several companies for its feasiblity as a standard for employee identification.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.18 **Epidemiological Study of Genetic Disorders in Adults

Category - 1 File Number: 34-7-2-39
Contractor - University of British Columbia (Dr. T.W. Anderson)
Vancouver, B.C.

It is proposed to continue funding the epidemiological study of genetic disorders among adults in British Columbia. Genetic disorders among a cohort of nearly 20,000 persons born before 1952 will be analyzed using the most recent classification codes.

This study is complementary to the earlier British Columbia study of childhood genetic defects among a cohort of nearly 60,000 individuals born between 1952 and 1982. The earlier AECB-funded study was completed in FY 85/86 with the recommendation that adulthood genetic defects among those born prior to 1952 should also be investigated to minimize any bias of underestimating the risk of radiation-induced genetic defects.

It is anticipated that the results of the study will improve the risk estimates for radiation-induced genetic disorders.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$20,000.00	$70,000.00
Actual Spending:	$0.00	$49,640.00	$21,845.00 (Estimate)	$71,485.00 (Estimate)

Contract Completed: No

COMMENTS: This study is in progress. The results of the study are expected to be complementary to a related study of childhood genetic disorders (84.8.1).

RESULTS: Coding of various genetic disorders among adults, aged 25 years or more, was completed. A spot check of coding accuracy is in progress.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.19 In Vitro Study of the Search for Radio-Sensitive Subpopulations in Humans

Category - 3

It is proposed to fund the study of the search for a radio-sensitive human subpopulation by investigating the sensitivity of progenitor cells in human bone marrow. Bone marrow progenitor cells obtained from healthy volunteers will be irradiated with x-rays and the sensitivity of these cells to x-rays will be measured using fluorescent-labelled monoclonal antibodies of human superoxide dismutase.

Irradiation of bone marrow progenitor cells is a major cause of radiation-induced leukemia. Recent animal studies have demonstrated the existence of a radio-sensitive subgroup of progenitor cells in bone marrow, and the size of this subgroup is thought to vary from one animal to another, depending on their relative radio-sensitivities. No such studies have been done in humans. If such a subpopulation is found to exist in humans, it will influence our understanding of the dose-effect relationship for the induction of leukemia.

It is anticipated that the results of the study will be used to demonstrate whether or not there exists a subpopulation in Canada which is more radio-sensitive to the induction of leukemia. If such a subpopulation is found to exist, measures may be able to be taken to protect it against radiation-induced leukemia. Additionally, identification of such a subpopulation would result in the improvement of risk estimates for radiation-induced cancers. (A joint study with AECL and the University of Manitoba on an equal cost-sharing basis.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$53,000.00	$20,000.00	$73,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.20 **Screening of Human Populations for Abnormal Radiosensitivity

Category - 1 File Number: 34-7-2-55
Contractor - Atomic Energy of Canada Limited
(Dr. N.E. Gentner, Dr. D. Morrison)
Chalk River, Ontario

It is proposed to fund a project which is intended to develop a relatively inexpensive and rapid assay to screen for inherited differences in radiosensitivity of individuals.

This project is proposed because in recent years, there has been "increasing recognition that there are human genotypes that confer both increased cancer risk and abnormal cellular sensitivity on exposure to carcinogenic agents, including ionizing radiation." Subgroups of human populations possessing these genotypes affect the distribution of risk. Depending on the degree of heightened sensitivity, the average dose-response relationship may significantly underestimate the risk for low dose or low dose-rate exposure of the sensitive individuals. The carriers of the "defective" genotypes are often not identifiable by common clinical tests. An ability to detect such persons on an occupation-wide basis could lead to improved protection for radiation workers and greater comprehension of how risk is distributed. An appreciable side-benefit could accrue from the practical application of such a screening assay: persons identified as "normal" would be somewhat less at risk than was previously supposed. The principle of such an assay currently exists in the cultured fibroblast, colony-forming ability assay. However, the fibroblast assay is too labour-intensive and expensive (estimated cost approximately $5,000 per strain (assay procedure) to test for sensitivity to ionizing radiation) to be used in screening large numbers of persons, and additionally too slow (establishment of the primary culture and survival analyses can take 6 to 8 months).

It is anticipated that the results of this study will lead to a technique for routine screening for inherited differences in radiosensitivity of subpopulations of radiation workers and others. Information obtained from routine screening of these subpopulations may impact upon the exposure-risk estimates currently forming the basis for the AECB occupational limits for exposure to ionizing radiation due to a necessary reevaluation of the distributions of risk derived from epidemiological studies. (A joint study with AECL on an equal cost sharing basis.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$101,000.00	$173,000.00	$274,000.00
Actual Spending:	$0.00	$72,526.62	$199,890.38 (Estimate)	$272,417.00 (Estimate)

Contract Completed: No

COMMENTS: The contractors have developed a "grow-back" procedure for assessing the relative detriment, occasioned by a given ionizing radiation exposure.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: The panelists reviewed several documents, including one major Milestone Report for Phase I of the project, and attended two meetings at the AECB headquarters. Significant comments were submitted by several of the panelists on the statistical analysis of the data, and the requirement of an ethics committee to oversee the work. In addition discussions were entered into (at the second meeting) concerning selection of suitable study populations for Phases II and III. It is difficult to assess at this time the impact of the panel on the project. The importance of the comments on statistical analysis and direction of Phases II and III will become more apparent during FY 87/88.

85.8.21 **Epidemiological Study of Lung Cancer among Uranium Miners of Eldorado Resources Ltd.

Category - 1 File Number: 34-7-2-60
Contractor - National Cancer Institute of Canada (Dr. G. Howe)
Toronto, Ontario

It is proposed to fund the ongoing epidemiological study of lung cancer among uranium miners of Eldorado Resources Ltd (ERL). In this phase of the study, smoking data of the miners will be collected and analyzed and the risk estimates for lung cancer will be re-evaluated taking smoking data into account.

Previous risk estimates for lung cancers obtained from the study of uranium miners of Eldorado Resources Ltd. did not take smoking into account. Because of the known association between smoking and lung cancer, it is important to correct the risk estimates for the influence of smoking.

It is anticipated that the results of the study will improve the risk estimates for lung cancer due to exposure to radon daughters. (This a joint study with the National Cancer Institute of Canada (NCIC).)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$45,000.00	$0.00	$45,000.00
Actual Spending:	$0.00	$52,624.00	$2,300.00 (Estimate)	$54,924.00 (Estimate)

Contract Completed: No

COMMENTS: The contractor's actual costs were higher than the estimate by the AECB staff, because of additional expenditures due to data collection from provincial data sources.

RESULTS: The preliminary results of the study indicated that the observed number of lung cancers among former ERL miners was 1.89 times the expected number in the control population. A final report of the study together with revised risk estimates for lung cancer due to exposure to radon daughters is expected by the end of August 1987.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

85.8.22 In Vitro and In Vivo Studies of the Effects of Ionizing Radiation on the Developing Central Nervous System

Category - 3
Contractor - University of Manitoba (Dr. T.V.N. Persaud)
Winnipeg, Manitoba

It is proposed to fund the in vitro and in vivo studies of the effects of exposure to external gamma radiation on the developing central nervous system of rat and monkey embryos, using whole embryo culture.

It is anticipated that an increasing number of Canadian women will seek employment in the nuclear industry, where, in some cases, exposure of embryos or fetuses may occur. Although mental retardation has been found to be the major developmental defect among those who received in utero exposure in the nuclear explosion in Japan, very little information is available in the literature about the effect of radiation on the function and structure of the brain. This study will help in the understanding of the problem.

It is anticipated that the results of the study will assist in the quantification of the risk of in utero exposure to ionizing radiation on the developing central nervous system. (This is a joint project with the University of Manitoba, which will contribute $160K to the project over the next three years.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$55,000.00	$95,000.00

Contract Completed: N.A.

COMMENTS: The priority of this project was raised at the request of RPD. A work statement was prepared during the period. A satisfactory proposal was received from the University of Manitoba. This study is expected to be initiated in June 1987.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H1: The work statement of this study was reviewed by the review panel. As a result of this review, the scope of the study was extended to include an in vivo component as well.

86.8.2 Sensitivity of Bronchial Epithelial Cells to Alpha Radiation

Category - 3

It is proposed to investigate the relative sensitivities of human bronchial epithelial cells to alpha radiation of energies of 8 MeV and below. This laboratory study will focus on the production of non-lethal chromosome aberrations in cells grown in a culture medium.

This study is proposed because the process of initiating lung cancer in humans by exposure to alpha radiation (such as is believed to occur in uranium mines) is not well understood. The cells of the bronchial epithelium which, upon absorption of alpha energy, initiate the development of lung cancer have not been identified with certainty.

It is anticipated that the findings of this study will provide information that is pertinent to understanding the mechanism of lung cancer induction by alpha radiation. (The proponents of this project formed a working group of Joint Panel on Occupational and Environmental Research for Uranium Production.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$60,000.00	$100,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.3 Adapting Dosimetric Models for Use on AECB EDP

Category - 1 File Number: 34-7-2-66

It is proposed to extract respiratory tract and gastrointestinal tract dosimetric models from the AECL main dosimetric model called GENMODE, and to translate them into a form for use by the AECB EDP system. Metabolic data that are part of GENMODE will be presented on a database format on separate diskettes.

GENMODE is a general dosimetric model that combines the ICRP lung model, a gastrointestinal tract model, and a compartment model for uptake and retention of radionuclides by the body's organs. Metabolic parameters regarding organs and compartments, as well as radionuclides of concern in occupational and environmental radiation protection are assembled in a database. The dose to target organs, the Committed Effective Dose Equivalent following unit intake and the subsequent excretion rates can be computed from GENMODE and its associated database. For regulatory activities, it is possible to split GENMODE into autonomous sub-programs that can be used on microcomputers to calculate ALIs, DACs, excretion rates and Committed Effective Dose Equivalents under specific conditions. The various sub-programs and databases can be made compatible to cover a range of routine and accident situations encountered by licensees of the Board.

The availability of dosimetric programs and data bases will enable the Board staff to determine more easily operational ALI and DAC values, when needed, and to assess the adequacy of monitoring techniques under routine and accident situations.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$40,000.00	$20,000.00	$60,000.00

Contract Completed: N.A.

COMMENTS: Project cancelled and is to be replaced by project 87.8.1.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.4 Study of the Health Effects of Low-Level Exposure to Environmental Radiation in Port Hope

Category - 3

By means of a literature review, interviews, and case control studies, it is proposed to: a) evaluate the health effects of low-level exposure to environmental radiation; measure the magnitude of risk of lung cancer induced by low-level alpha radiation; study the association between gamma radiation and leukemia; and b) determine the importance of environmental radiation in relation to the other major cancer risk factors and assist in the establishment of a relationship between radiation-induced cancer and radiation exposure.

This project is proposed because, in 1980, a case-control study of lung cancer among Port Hope residents turned out to be inconclusive. The earlier study was conducted in order to try to evaluate the relative importance of domestic radiation exposure due to radioactive contamination of homes from industrial sources. Based on 12 years of lung cancer incidence (1966-1977) and the information from radiation surveys, the study showed an elevated risk ratio in homes with elevated radon levels. However, because of the limited sample size, the association between lung cancer and radiation contamination did not reach a statistically significant level. Also, the design and analysis of the study have been criticized because of the small number of cancer cases, the questionable selection of controls, the effect of potential co-carcinogens which were not investigated, and the absence of investigations on leukemia. It is now possible to extend the 1980 study by utilizing 18 additional cases of lung cancer (compared to the original 27 in 1980 study) and by including all cases of leukemia. Controls will be selected and co-carcinogens investigated according to state-of-the-art techniques, and a new questionnaire will be compatible with that of the 1980 study, with additional questions on dietary habits. It is intended to include workers from Eldorado Nuclear Ltd. in the study.

It is anticipated that the results of the study will complement the Board's knowledge of the long-term effects of exposure to low-level alpha and gamma radiations, and will bring information on how the aging of an exposed population influences the results of epidemiological studies. The proposed study should also indicate how other parameters such as dietary habits, medical history and other non-radiological carcinogens influence the outcome of a case-control study on the health effects of radiation.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$65,000.00	$125,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H2 (Planned)

86.8.6 Study of the Recovery of Kidney Tissue from the Toxic Effects of Uranium

Category - 3

It is proposed to conduct animal experiments with a view to re-evaluating the chemical toxicity of uranium. The study will concentrate on the extent and rate of recovery from tissue damage following nephrotoxic effects, and will seek to select routine urine tests that will give good indications of kidney function.

There is evidence from animal experiments that observable kidney damage occurs at concentrations of uranium in tissue, as low as 1 microg/g, although the present recommended maximum permissible limit is 3 microg/g. However, the links between histopathology and kidney function are uncertain, and although recovery of renal function has been observed, the rate and the extent of tissue recovery from damage caused by uranium is not well known, and no simple test exists yet that can be used to monitor the renal functions of uranium workers.

It is anticipated that the results of the study will increase the Board's knowledge of nephrotoxic effects associated with uranium intake, and will indicate the extent and rate of tissue recovery. The results derived from the routine urine tests are expected to indicate the feasibility and reliability of the monitoring of renal functions in uranium workers.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$60,000.00	$120,000.00	$180,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.8 Cancer Morbidity Follow-Up Feasibility Study Using the National Dose Registry of Canada

Category - 3

It is proposed to determine the feasibility of using morbidity data sources available in Canada for individual medical follow-up studies by attempting to link the National Dose Registry with the Alberta Cancer Registry to determine any association between occupational radiation exposure levels and cancer incidence. It is further proposed to use a case-control methodology in which groups of individuals are selected based on whether or not they have the disease, in this instance, as collected by the Alberta Cancer Registry.

This feasibility study is proposed because morbidity data will greatly assist the AECB in determining whether any excessive health effects or risks exist due to exposure to certain potentially hazardous environmental, occupational or other factors. This information will both complement and supplement mortality data available through the Canadian Mortality Data Base by providing a more sensitive measure (than mortality data alone) of the differences in risk from exposure to potentially hazardous environmental, occupational or other factors and a possible earlier detection of any potential health hazard.

It is anticipated that this study will provide the AECB with: (i) the ability to draw upon more cancer data from Canadian sources; and (ii) the opportunity to detect the occurrence of any non-fatal or rare cancers. In addition, it will assist the AECB in identifying areas of occupational, environmental, and other health risks for the general public, will aid the AECB in its regulatory activity and finally will help in providing information for the assessment of exposures and occupational hygiene practices.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$20,000.00	$50,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.9 **Adequacy of Relative and Absolute Risk Models for Lifetime Risk Estimates of Radiation-Induced Cancers

Category - 1 File Number: 34-7-2-61
Contractor - Ms. M. McBride
Vancouver, B.C.

It is proposed to fund a literature review to examine the degree of adequacy with which relative and absolute risk models permit lifetime risk estimates for different cancers.

There is some controversy as to which of the two risk models, relative or absolute, are applicable for lifetime risk estimates. Since the two models often result in different risk estimates, depending on a number of factors such as the type of cancer and the ages of the individuals within the cohorts, it is important to understand their strengths and weaknesses in different applications.

It is anticipated that the results of the study will enable the AECB to improve the understanding of the relative strengths and weaknesses of the two models for lifetime risk estimates for radiation-induced cancers.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$12,000.00	$0.00	$12,000.00
Actual Spending:	$0.00	$20,475.00	$0.00 (Estimate)	$20,475.00 (Estimate)

Contract Completed: No

COMMENTS: The final report of the study is expected in July 1987. The contractor's actual expenditures were higher than the original estimate by the AECB staff because of additional cost involved with the use of computer time.

RESULTS: Preliminary results indicate that, for lifetime risk estimates, the relative risk model is somewhat better than the absolute risk model if the sex and age at exposure of the population are known.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H2: The progress of the study was reviewed twice by the review panel of Provincial Epidemiologists. This review has resulted in additional computer testing of the two models using Canadian data on cancer mortality.

86.8.10 Bibliography of Publications on Computerized Record Linkage in Health Research

Category - 3

As a follow-up to the Workshop on Computerized Record Linkage in Health Research, May 1986, it is proposed to establish an updated bibliography of publications related to computerized record linkage in health research. The bibliography will be assembled on a micro-computer diskette in a format suitable for publication. The standard supporting software will make up-dating easy. One section of the bibliography will deal specifically with health effects of radiation.

The last bibliography assembled in this domain was prepared in 1970, by G. Wagner and H.B. Newcombe for the Medical Research Council of Canada. Since that time, computer techniques and the ethics of dealing with personal records in computer files have evolved considerably. It has also been shown that epidemiological studies can be powerful tools when they link health effects to large numbers of parameters, provided that linkage techniques between computer files are available and are ethically acceptable.

It is anticipated that the proposed bibliography will provide a comprehensive current list of all published work using record linkage for radiation and other health studies. Such a bibliography will be useful in disseminating information, in encouraging interaction and collaboration on future research, and in avoiding duplication of efforts among departments and agencies. (This is a joint study between AECB and Statistics Canada.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$0.00	$25,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.11 Hospital Record-Keeping System for Case-Control Epidemiological Studies - A Feasibility Study

Category - 3

It is proposed to conduct a feasibility study to modify hospital record-keeping systems to facilitate inexpensive case-control epidemiological studies of radiation-induced health effects.

Case-control studies of radiation-induced health effects can be conducted inexpensively using hospital records. However, the record-keeping systems in Canadian hospitals are not currently in a format to facilitate such studies.

It is anticipated that the results of the study will determine the feasibility of modifying hospital record-keeping systems. If the modification is feasible, several epidemiological studies of radiation-induced health effects can be conducted inexpensively to improve risk estimates.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$0.00	$50,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.12 Selection of Control Groups for Use in Epidemiological Studies of Radiation-Induced Health Effects

Category - 3

It is proposed to fund the development of a unified system of selecting control groups for use in epidemiological studies of radiation-induced health effects.

One of the major problems in interpreting the results of epidemiological studies of groups exposed to ionizing radiation is the general lack of comparability between different studies of similar groups. The main source of the problem is the variation of the quality of control groups used in the different studies. It is therefore essential to develop a comprehensive system or methodology for selecting control groups for use in Canadian epidemiological studies of radiation health effects. Lack of uniformity in selecting control groups has also been recognized as a weakness in epidemiological studies in member countries of the OECD. (Dr. Joan Davies, OECD, Report No. SAN/DOC(84)5.)

It is anticipated that the results of the study will provide a unified system or methodology of selecting control groups for use in epidemiological studies of radiation-induced health effects.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$30,000.00	$0.00	$30,000.00

Contract Completed: N.A.

COMMENTS:

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H2 (Planned)

86.8.15 Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure

Category - NEW
Contractor - G.B. Hill Statistics Inc. (Dr. G.B. Hill)
Montreal, Quebec

It is proposed to continue funding the epidemiological study of thyroid cancer among Canadians who were exposed to radioactive iodines during diagnostic examinations.

This project is proposed because risk estimates for radiation-induced thyroid cancer are largely based on the incidence among those exposed to X-radiation. There is some controversy as to whether or not the same doses of I-131 and X-radiation are equally effective for the induction of thyroid cancer. A pilot study (84.8.13), jointly funded by the Alberta Cancer Board and the AECB, recommended a full-scale study at the national level to investigate the relative biological effectiveness of X-radiation and I-131.

The results of the study are expected to refine the risk estimates for radioiodine-induced thyroid cancers, and to determine whether or not equal (thyroid) doses of I-131 and X-radiation are equally effective in the induction of thyroid cancers. This is a joint study with nine provincial cancer registries and the Department of National Health & Welfare which will contribute $271K to the project over the next two years.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$50,000.00	$21,000.00	$71,000.00

Contract Completed: No

COMMENTS: This project is expected to be initiated in FY 87/88. All ten provincial cancer registries are now participants in the study.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H2: The review panel of Provincial Epidemiologists reviewed the design of the study and recommended several changes which were made. The most significant change was the increase in the desired number of cases to 1200.

86.8.17 **Distribution of Fatal Risk in "Safe" Industries - Supplement

Category - NEW File Number: 34-9-5-4
Contractor - Social Data Research Ltd.
(Ms. C.K. Davis, Dr. W.F. Forbes, Ms. L.M. Hayward)
Hamilton, Ontario

It is proposed to analyze further the data gathered for the research project "Study of the Distribution of Fatal Risk in 'Safe' Industries" (84.8.12), and produce tables and text that discuss the numbers of workers at different occupational risk levels in Canadian industries. These tables and text will be incorporated into the final report for the initial project.

This project is proposed because, on reviewing the final report for project 84.8.12, the AECB decided that an additional analysis of the data beyond what was required for the initial project would be of use. The additional analysis is needed in order to reveal the number and percentage of workers (in selected Canadian industries) for whom the risks of fatal injury are various multiples of the risk for that industry.

The anticipated use of the findings of this study is the same as for the initial project, namely that results will help in judging whether or not the dose limits for radiation workers represent too high an individual risk.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$3,000.00	$0.00	$3,000.00
Actual Spending:	$0.00	$3,110.00	$0.00	$3,110.00

Contract Completed: Yes

COMMENTS:

RESULTS: The distribution of high-risk occupations was found to vary widely between the different industries in Ontario for a number of reasons including the fact that insufficient data in some instances resulted in less than desirable reliability. However, in spite of various data limitations, a number of occupations were found to have above average fatal risk rates in several industries, including Material Handlers & Related, N.E.C. (SOC-9319), Welders and Flame Cutters (SOC-8335), Truck Drivers (SOC-9175) and Mechanics & Repairmen, except Electrical (SOC-8589). The majority of occupations had rates below or close to the industry average; however, between 15% and 30% of the occupations in any given industry had fatal risk rates above the industry average. When the number of workers involved in different occupations was considered, between 18% and 40% of workers were in occupations with above the industry average risk rate.

EVALUATION: The contractor successfully completed the tasks set out in the work statement. The report contains information on non-radiological risk distributions in Ontario-based industries which, when compared with appropriate radiological risk distributions, should permit the AECB to assess further the adequacy of the current AEC Regulations, with respect to the distribution of radiological risk in the nuclear industry. Work is currently underway 'in-house' to compare radiological and non-radiological risk distributions in Ontario-based industries.

PUBLICATIONS: INFO 0206, "The Distribution of Fatal Risk in Ontario Industries".

REVIEW PANEL ACTIVITIES:

86.8.18 Ontario Miners Mortality Study - Update

Category - NEW File Number: 34-7-2-35
Contractor - Ontario Ministry of Labour (Mr. R.A. Kusiak)
Toronto, Ontario

It is proposed to fund the ongoing investigation of the cause of excess lung cancer among gold miners in Ontario and to update the mortality analysis for Ontario uranium miners for the period from 1981 to 1984 and for the gold miners from 1977 to 1984, in order to re-evaluate the risk of lung cancer per unit exposure.

This project is proposed because this is an extension of the Phase II study where excess lung cancer among gold miners and the influence of smoking on the incidence of lung cancer among uranium miners were investigated. The Phase II study recommended that the mortality analysis of gold miners should be extended from 1977 to 1984 to evaluate the impact of gold mining experience on the risk estimate for lung cancer among uranium miners.

It is anticipated that the results of the study will be used to improve the risk estimates for radiation-induced lung cancers. (A joint study with the Workers' Compensation Board of Ontario and Ontario Ministry of Labour on an equal cost-sharing basis.)

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$187,000.00	0.00	$25,000.00	$212,000.00
Actual Spending:	$186,941.00	$0.00	$25,000.00 (Estimate)	$211,941.00 (Estimate)

Contract Completed: No

COMMENTS: This study is expected to be initiated during the fall of 1987.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.19 **Cytogenetic Measurements of the Relative Biological Effectiveness of Tritium

Category - NEW File Number: 34-7-2-70
Contractor - Bio-Mutatech Incorporated (Dr. J.A. Heddle)
Toronto, Ontario

It is proposed to measure the relative biological effectiveness of tritium (as compared to that of 200 kVp x-rays) for the induction of a) chromosomal aberrations in lymphocytes and b) reciprocal translocations in spermatogonia. The dose-response curves for each of the endpoints scored will be plotted and analyzed in a statistically rigorous manner. The experiments are to be carried out on the same strain of mouse, using the same irradiation facilities and protocols as those in Project 84.8.15 ("Measurement of RBE for Tritium for Induction of Myeloid Leukemia").

The radiological effects of tritium are of special concern to Canada because of the CANDU reactor technology which utilizes deuterium oxide as a moderator. As a consequence, tritium is formed and, inevitably, some of the atomic radiation workers are exposed to it. This tritium, usually in the form of tritiated water, becomes distributed throughout the body and incorporated into many molecules including lipids, proteins and DNA. Upon decay of the tritium, the beta particle may enter or arise in the cell's nucleus and cause chromosomal aberrations and gene mutations. The dose distribution among nuclei at low doses may be different from that of a corresponding average absorbed dose of x-or gamma-rays. In addition, the transmutation of 3H or 3He during the tritium decay may cause DNA damage beyond that from the tritium beta-ray. Hence the biological effectiveness of tritium may not be the same as that of 200 kVp x-rays, often taken as a standard. For this reason, this study of the RBE of tritiated water for the production of the genetic endpoints indicated above, as well as for the induction of myeloid leukemia in mice (Project 84.8.15), is being supported.

It is anticipated that the results of this study will enable AECB staff to quantify the risk of inducing myeloid leukemia based on cytological measurements, carried out long before the onset of this specific cancer.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$94,000.00	$119,000.00
Actual Spending:	$0.00	$25,000.00	$93,720.00 (Estimate)	$118,720.00 (Estimate)

Contract Completed: No

COMMENTS: Practical constraints placed upon the study by the available irradiation facilities at CRNL dictated a reduction (by one) in the number of radiation doses in both the spermatocyte and lymphocyte studies to three radiation doses: 1.5, 3.0 and 4.5 Gy. Dose data for individual mice (as opposed to group data) will be obtained.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: This project has only recently been commissioned by the AECB. The panelists reviewed several documents and attended one meeting at the AECB headquarters at which all of the major requirements were discussed with the contractor for the initiation of the contract.

86.8.20 **Measurement of Thyroid Burdens using Radiation Survey Meters

Category - NEW File Number: 34-7-2-72
Contractor - Radioprotection Inc. (Mr. M. Deschamps)
St. Julie, Quebec

It is proposed to fund a study to investigate whether the measurements obtained using devices, such as hand-held radiation contamination meters and gamma survey meters, currently used by AECB licensees and staff, are reliable in estimating thyroid burdens of I-125, I-123, I-131 and Tc-99m, in radiation workers. The contamination/survey meters and the conditions under which they are used at nine AECB licensee facilities across Canada will be investigated.

This study is proposed because the Radiation Protection Division (RPD) of the AECB requires more quantitative information on the thyroid burdens of licensees who use radioisotopes, and currently some licensees do not have any access to routine thyroid monitoring facilities.

It is anticipated that the results of this study will enable AECB staff to: a) better assess reports of the thyroid burdens of radioisotope workers in a cost-effective manner; and b) evaluate a licensee's use of those devices for thyroid measurement as recommended in guidelines or as required as a licence condition.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$18,000.00	$0.00	$18,000.00
Actual Spending:	$0.00	$18,235.02	$0.00 (Estimate)	$18,235.02 (Estimate)

Contract Completed: No

COMMENTS: The final report is being prepared.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.21 **Catalogue of Data on Uranium Uptake, Organ Burden, and Excretion

Category - NEW File Number: 34-7-2-73
Contractor - Senes Consultants Ltd. (Mr. M. Davis)
Willowdale, Ontario

In preparation for the research Project No. 87.8.1, it is proposed to draw up a catalogue of the sets of data on uranium intake, organ burden, and excretion from which current biokinetic and dosimetric models have been based.

The AECB staff is in the process of preparing the work statement for the research project entitled "Compilation and Critical Evaluation of Data Used to Derive Current Dosimetric Models for Uranium". In order to establish a statement of work which is accurate and complete and takes into account the actual availability of data and information, it is necessary to assemble a catalogue of the data upon which current biokinetic and dosimetric models are based.

It is anticipated that the project will provide the AECB research staff with the information necessary to produce an adequate work statement for the proposed Project No. 87.8.1 (see Project 87.8.1).

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$9,000.00	$0.00	$9,000.00
Actual Spending:	$0.00	$9,000.00	$0.00	$9,000.00

Contract Completed: No

COMMENTS: Work completed. Final report is in preparation.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.8.22 **Literature Review of Studies on Uptake Retention and Distribution of Radionuclides by the Foetus

Category - NEW File Number: 34-7-2-74
Contractor - Atomic Energy of Canada Limited (Dr. J.R. Johnson)
Chalk River, Ontario

It is proposed to conduct a comprehensive review of the literature concerning the studies of uptake and retention of radionuclides by the foetus following maternal intake.

An accurate assessment of dose to the foetus requires the knowledge of the biological parameters for uptake and retention of radionuclides by the foetus. To date, little information is known regarding these parameters and the factors which influence them. As a first step in obtaining reliable data on these important parameters, a literature review is required.

The results of the study will enable us to update the information on uptake and retention of radionuclides by the foetus. This will facilitate calculation of internal dose to the foetus, and also identify areas in which further information is required.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$15,000.00	$0.00	$15,000.00
Actual Spending:	$0.00	$15,000.00	$0.00 (Estimate)	$15,000.00 (Estimate)

Contract Completed: No

COMMENTS: The final report is expected by the end of August 1987.

RESULTS: Preliminary results indicate that the amount of data in the literature on foetal uptake and retention of radionuclides, such as uranium, thorium and their decay products, is limited. Much more experimental work in this area is needed, according to the recommendations contained in the report.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

MISSION OBJECT 9 - REGULATIONS & REGULATORY PROCESS DEVELOPMENT

84.9.3 Methodologies for Evaluation of AECB Regulatory Programs

Category - 1* File Number: 34-11-3-0
Contractor - Yarranton Holdings Ltd. (G.A. Yarranton)
Calgary, Alberta

It is proposed to conduct a literature search and to prepare an annotated bibliography of program evaluation studies and reports, and other relevant material concerned with the evaluation of regulatory programs similar to the regulatory programs of the AECB. The project will also include a review and summary of the advantages and disadvantages of the various methods of evaluation used and will indicate the type of information required to use the various evaluation methods. Later phases of this research may be used to develop appropriate methodologies if none exist.

This project is being proposed because Treasury Board Policy Circular 1977-47, "Evaluation of Programs by Departments and Agencies" states that: "Departments and agencies of the federal government will periodically review their programs to evaluate their effectiveness in meeting their objectives and the efficiency with which they are being administered." Currently, there is limited information on methodologies for evaluating regulatory programs in Canada. However, regulatory agencies in other countries may have some experience in this area, and Canadian and foreign experience in the program evaluation of other regulatory areas may be applicable to the Canadian nuclear regulatory program.

It is anticipated that the information obtained from this project will be used in the design of the program evaluation assessments and studies in the implementation of the AECB's Program Evaluation Plan. The information would also be made available to other interested Canadian regulatory agencies, through the OCG Working Group on the Evaluation of Regulatory Programs.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$30,000.00	$8,000.00	$0.00	$38,000.00
Actual Spending:	$37,967.00	$0.00	$0.00	$37,967.00

Contract Completed: Yes

COMMENTS:

RESULTS: The report contains a bibliography consisting of 280 abstracts assembled from an extensive search of the international literature. Each cited publication describes or uses methods applicable to the evaluation of regulatory programs. The report reviews the methodologies found in the literature, identifying the most relevant references for each step in program evaluation. It examines the applicability, the advantages and disadvantages of the different evaluation methods, and makes recommendations about the selection of methods and their application to the AECB program.

EVALUATION: The contractor has carried out his work fully in accordance with the work statement, according to the Evaluator and Scientific Authority. To date, limited use has been made of the results of the report. The final judgement on the value of the contract report must await the assessment of its application to the AECB's Program Evaluation of various regulatory activities.

PUBLICATIONS: INFO 0200, "Methodologies for Evaluation of AECB Regulatory Program".

REVIEW PANEL ACTIVITIES:

84.9.7 AECB's Process of Consultation with Employees of Its Licensees

Category - 1* File Number: 34-11-0-2
Contractor - IEC Beak Consultants Ltd. (D.R. Hart)
Mississauga, Ontario

It is proposed to continue funding a study and evaluation of the processes through which the AECB consults with workers (or their representatives) employed by licensees when proposing regulations or setting licence conditions concerning health and safety which might affect workers.

This study is proposed because employees who may be directly affected by AECB licences or regulations concerning radiological health and safety have generally not been widely consulted in the regulation-making or licensing procedure through methods other than the regulatory document process.

It is anticipated that the results of this study will be used to help the AECB review its methods of consulting with employees (or their representatives) of licensees. Furthermore, it is expected that these results will indicate whether additional formal steps in the overall public consultation process are required.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$36,000.00	0.00	$0.00	$36,000.00
Actual Spending:	$35,596.00	$0.00	$0.00	$35,596.00

Contract Completed: Yes

COMMENTS:

RESULTS: The study contained a number of recommendations to improve the AECB process of consultation with employees at licensed facilities. Additional recommendations, related to improved targeting of consultation with employees, included more specific guidelines for the naming of ARW's by employers and for the updating of licensee contacts for each licence held.

EVALUATION: The contractor carried out the work in a satisfactory manner. The report is very revealing in the information it conveys regarding the need for more and better information dissemination to and training of employees of licensees. It confirms both the lack of understanding by employees of the AECB's consultation process and of the technical content of consultative documents, and also confirms the frustration of employees as to how to make worthwhile comments on specific consultative documents and on the consultative process itself. This project is likely to influence the mechanism for future consultations between the AECB and workers' representatives. Over the long term, the AECB is likely to receive good value for the money expended.

PUBLICATIONS: INFO 0197, "Evaluation of the AECB's Process of Consultation with Employees of its Licensees".

REVIEW PANEL ACTIVITIES:

85.9.2 **Socio-Economic Impact Analysis of Proposed General Amendments to Atomic Energy Control Regulations

Category - 1 File Number: 34-11-4-0
Contractor - Econosult Inc. (J-F Gautrin)
Montreal, Quebec

It is proposed to investigate the socio-economic impact of the intended General Amendments to the Atomic Energy Control Regulations. The incremental costs and benefits of these regulations to the Canadian nuclear industry and other users of radioactive materials as well as to Canadian society in general will be predicted and subjected to cost-benefit or related analysis.

This work is being proposed in accordance with Treasury Board's previous requirements concerning new major health, safety and fairness regulations. It is being continued under the government's policy on the need for a Regulatory Impact Analysis Statement (RIAS). It is not yet known whether these amendments will have a "major" impact as defined in Chapter 490 of Treasury Board's Administrative Policy Manual, and hence the need for a socio-economic impact analysis has not yet been confirmed. However, the AECB anticipates that the level of public concern likely to be produced by these amendments will justify the performance of such an analysis. The AECB must determine whether any part of the proposed amendments to the regulations would pose unjustified costs and whether these amendments are the most effective means of meeting the objectives of health, safety, and environmental protection.

It is anticipated that the results of this study will aid the AECB in its review of the proposed amendments. In addition, this study is expected to be used to satisfy Treasury Board requirements under its new Regulatory Reform Strategy.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$140,000.00	$0.00	$140,000.00
Actual Spending:	$0.00	$91,900.00	$50,165.00 (Estimate)	$142,065.00 (Estimate)

Contract Completed: No

COMMENTS: Work in progress. The contractor was occupied with assembling the basic information through questionnaires and interviews, on the anticipated costs and benefits to licensees, of the proposed amendments.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES: Review Panel H8: The Senior Review Group (SRG) reviewed and gave final approval to: the original work statement; the recommendations on the choice of contractor; the questionnaire (prepared by the contractor and distributed to selected licensees); and the revised work statement. It has also commented and given advice to the contractor on procedures to be followed in interviews and correspondence between the contractor and AECB licensees and in the gathering of information on costs and benefits.

86.9.1 Uranium Mine Radiation Safety Course

Category - 1* File Number: 34-4-1-0
Contractor - Canadian Institute for Radiation Safety (Dr. E. Becker)
Elliot Lake, Ontario

It is proposed to continue to fund the two sessions of the Uranium Mines Radiation Safety Course (UMRSC), one to be held in the spring in Saskatoon, Saskatchewan, the other in the autumn in Elliot Lake, Ontario. (The first course in this series was held in Elliot Lake in May, 1976.)

This course is designed to provide participants with the basic understanding of radiological hazards to workers and to the environment. It also presents practical approaches to deal with these hazards. The philosophy and regulatory approach of the AECB are discussed.

It is anticipated that this course will continue to provide uranium mine radiation safety principles to mine supervisors, inspectors and operations personnel, and to representatives from regulatory agencies, mining companies and unions, who are directly involved in radiation safety.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$397,000.00	$75,000.00	$80,000.00	$552,000.00
Actual Spending:	$397,000.00	$92,129.00	$0.00	$489,129.00

Contract Completed: Yes

COMMENTS: The two courses were carried out successfully in FY 86/87.

RESULTS: A total of 34 participants attended the two courses offered in FY 86/87.

EVALUATION: The contractor administered successfully the two courses according to the work statement and according to the training objectives outlined by the AECB. Participants attain a higher degree of understanding of radiation hazards, radiation protection and the regulation of uranium mines and mills in Canada. The AECB continues to derive good value for money from this ongoing project.

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.9.2 **Development of a Radiation Safety Training Module for Use in Canadian Uranium and Thorium Mines

Category - NEW File Number: 34-4-1-2
Contractor - Canadian Institute for Radiation Safety (Dr. E. Becker)
Elliot Lake, Ontario

It is proposed to fund a project to develop and produce a training module in radiation safety to promote a uniform standard of training for mine workers in Canadian uranium and thorium mines. This module is to be entitled Atoms and Nuclei. The topics of this module include: the different types of ionizing radiation; the properties and behaviour of uranium, thorium, radon and thoron and their daughter products, gamma, beta and alpha radiation. The emphasis will be on the development of a training course and training materials leading to a better understanding of health and safety of mine workers and given at a level which is understandable to them.

The module is to be designed to meet the standards and requirements set by the Atomic Energy Control Board's Uranium and Thorium Mining Regulations, made by the Board on 18 June 1986. The module will be a self-contained package including: training materials for each participant, a comprehensive guide for the instructor, training aids, laboratory exercises and an examination designed to test the knowledge acquired by the participants.

It is anticipated that the results will be used by the uranium mining licensees to satisfy some of the training requirements set out in the Uranium and Thorium Mining Regulations. In addition, a pilot project will be carried out to test the degree of understanding of the topics contained in the training module on a group of miners and mining supervisors during a licensee's regular training session in Elliot Lake and possibly at a Saskatchewan uranium mining facility.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$34,000.00	$33,000.00	$67,000.00
Actual Spending:	$0.00	$34,000.00	$32,990.00 (Estimate)	$66,990.00 (Estimate)

Contract Completed: No

COMMENTS:

RESULTS: A first draft of the Radiation Safety Training module was received in FY 86/87 and several classroom pilot runs have taken place in Saskatoon and Elliot Lake.

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

86.9.3 Review of Crisis Management Methods

Category - NEW

Based on the latest developments in crisis management, it is proposed to review AECB operations and corporate planning, to recommend which elements of crisis management should be included in corporate planning, and to advise on the preparation of a crisis management manual.

Although there are AECB documents that deal with emergency response at the working level (e.g., duty officer's handbook, divisional operating procedures), there is no corporate document that deals with broader questions such as:
- the establishment of a crisis team;
- communications with the public, who handles it, and how?
- chain of command in the absence of someone in the management structure;
- interaction with other government agencies;
- role of the AECB Emergency Response Coordinator.

The results of this review will assist AECB staff in updating corporate planning to address crisis management, and in preparing a detailed crisis management manual.

	Past Years	FY 86/87	Future Years	Total
Original Estimate:	$0.00	$25,000.00	$0.00	$25,000.00

Contract Completed: N.A.

COMMENTS: This project was not initiated this year and work will only be commenced if the proponent is unable to obtain the information through other channels.

RESULTS:

EVALUATION:

PUBLICATIONS:

REVIEW PANEL ACTIVITIES:

APPENDIX C

Project Numbers and Titles

APPENDIX C

Project Numbers and Titles

Nuclear Reactors

84.1.1	The Permeability of Containment Concrete for CANDU Reactors
84.1.2	Shut-Off-Rod Guide Tube Susceptibility to Deformation
84.1.4	The Degradation of Zirconium Alloys in Nuclear Reactors
84.1.6	Instrument Behaviour under Off-Normal Conditions
84.1.12	Criteria for Identification and Evaluation of Fire Hazards
84.1.13	Hydrogen Absorption in Zircaloy at High Temperatures
84.1.17	Computer Software Quality Assurance
84.1.19	Adequate Meteorological Monitoring
84.1.20	A Tool to Analyze Real-Time Programs
84.1.26	Review of Control Room Emergency Operating Procedures
84.1.27	Practices for the Upkeep of Overpressure Protection Devices
84.1.28	Flaw-Sizing Using Ultrasonic Techniques
84.1.30	Fuel/Moderator Interaction after Pressure Tube Rupture
84.1.31	Secondary Side Heat Sink Performance
84.1.32	Vibration Probe Monitoring of Structure Deterioration
84.1.38	Crack and Fracture Behaviour in Tough Ductile Materials
84.1.39	Mode Shape and Frequency Identification for Seismic Analysis
85.1.3	Reliability of Microcircuits in Nuclear Power Plants
85.1.4	Aerosols and Fission Product Transport
85.1.6	Vibration Forcing Function on Primary Pumps: Data Analysis
85.1.7	The Use of Full-Scope Simulators in Training and Qualification
85.1.8	Crack Propagation in Tough Ductile Materials
85.1.9	Ultrasonic Defect-Sizing Using Decibel Drop-Off Methods
85.1.10	Simulation of Darlington NGS Shutdown and Regulating Systems

85.1.11 Mode Shape and Frequency Identification for Seismic Analysis II

86.1.1 Selection of Equipment for Equipment Qualification

86.1.2 Technical Basis for Equipment Qualification Assessments

86.1.3 Survey of NPP Environments for Equipment Qualification

86.1.4 Assessment of NPP Aging and NPP Maintenance Programs

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86.1.10 Fuel Element Susceptibility to Bowing in Dryout Conditions

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